MECHANICAL ENGINEERING

· OCTOBER 1949 ·

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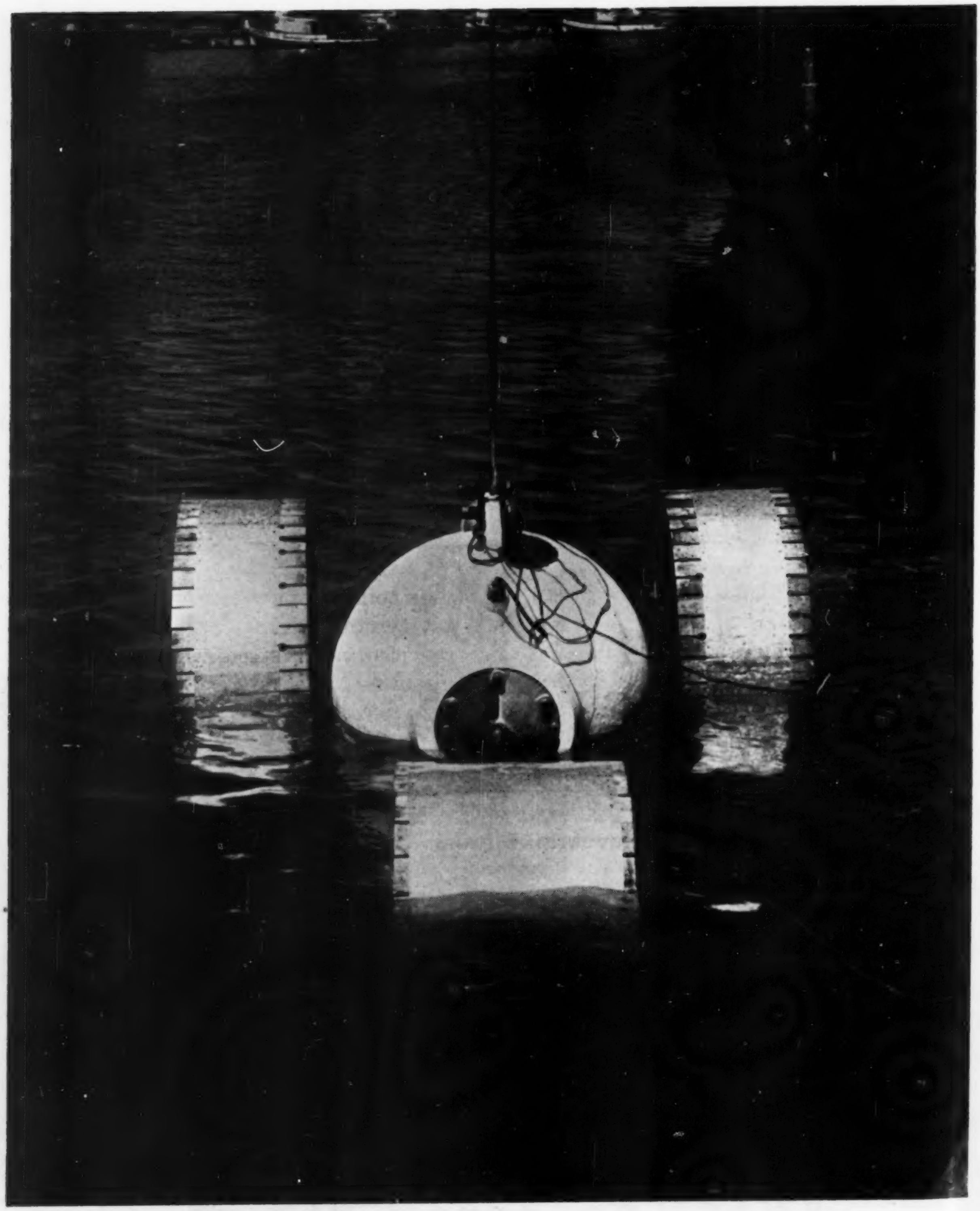

Exploring the Ocean's Depths

(Steel benthoscope, with which Mr. Otis Barton descended 4500 ft below the ocean's surface, is shown being lowered into the ocean during test dives. During early tests the wheels were lost. *See pages 842–843 for further details.)*

VOLUME 71
No. 10

MECHANICAL ENGINEERING

OCTOBER
1949

GEORGE A. STETSON, *Editor*

Edison—A Symbol

SEVENTY years ago—on October 19, 1879—Thomas A. Edison began the test of his incandescent electric lamp, with carbonized thread filament, that was to initiate a new era in artificial illumination. Hour after hour the lamp continued to give forth its steady light, and on October 21 Edison was convinced that his invention was a success. Thus, in America at least, Edison became a symbol of the electric light, and as such a symbol he will continue to be honored, in spite of developments that antedated or were contemporary with his, or those that have marked progress in the art throughout the past seven decades.

A glorious age of advances in science, engineering, industry, and material progress was unfolding seventy years ago in the United States and the Western World. Opportunities for enterprise in commerce, industry, transportation, and communication were practically unlimited. Economic, social, and political climate was favorable and stimulating. The incentives and rewards aroused energies and ambitions and provided personal and material satisfactions of an order seldom if ever realized in previous ages of history. Men who threw themselves into the rapid current of material progress or were drawn into it by force of circumstance, struggled hard through long wearying hours of work. There were vivid contrasts of fabulous wealth and degrading poverty, of personal triumph and tragedy, of slothful ease and grinding toil, of misused economic power and hopeless economic frustration, of too much elbow to elbow with too little. But out of it all material and social progress slowly emerged. Contrasts grew less sharp. The rigors of physical toil relaxed, hours of work decreased, and in the factory, the field, the market place, and the home, creature comforts, better education, better health, and a growing social conscience raised the general level of the standard of living of all citizens and accelerated the progress of social and economic equality toward which democracies must advance or lose their meaning and vitality.

In addition to being a symbol of the electric light Edison may also be considered a symbol of many other characteristics of the era in which he lived. It was the age of electricity, that great servant of modern man which has entered into almost every phase of life today. With the development of the uses of electricity, which became rapid as soon as central stations and transmission systems provided a dependable and economical source of power, the industrial arts became increasingly dependent on and enriched by science. The forces and materials of nature that had formed the basis of the industrial and mechanical arts since the beginning of time had been controlled and put to use by artisans and engineers with limited comprehension of fundamental sciences involved. Men cultivated the soil, wove fabrics, refined and fabricated metals, devised machines, utilized the energy of combustion, of wind and water, and designed and built structures of wood and stone, with only primitive and often incorrect knowledge of physics, chemistry, mathematics, and the life sciences. Traditional handicrafts and experience, coupled with intuition, ingenuity, and inventiveness, made it possible for the artisan to utilize forces and materials that he could feel and see and handle. But in an electrical age it was necessary for science and the arts to join hands in the fields of applied science and engineering, and the methods of analysis and the laboratory, that had been rather generally confined to the university, began to be followed by industry. Edison was in a sense, a symbol of this transfer of scientific to workshop practices, of the beginnings of the industrial research laboratory. Certain it is that he was one of the pioneers in this field, and that he made good use of teams of research and development workers in pursuing the inventions that flowed from his fertile brain.

Finally, in a sense, too, Edison stands as a symbol of the modern industrial counterpart of the flash-of-genius solitary inventor. He made inventions a business, as was typical of the age in which he lived, and he built up an organization of men and methods by means of which the fulfillment of needs was accomplished and new products and new industries were discovered and developed. No industrial organization today would dare face the future without hope of competitive advantages born of a group of research and development men probing into new ideas and perfecting and expanding older ones.

Thus it is that from many points of view Edison is a symbol of the flowering of the industrial era under the fruitful influences of applied science, especially electricity, and a system of enterprise that afforded abundant opportunities, incentives, and rewards.

Dilemma of the Atomic Age

NO one standing on the threshold of the electrical age would have predicted how greatly the material aspects of civilization would be enriched by developments in electrical science and engineering. Nor can anyone predict today what developments in atomic energy will mean to us and to future generations.

We look back over the last seven decades and see how rapid and how widespread were the discoveries of science

and the developments of engineering. The amazing record of science and engineering during the war is fresh in our memories. We know that both scientific and industrial research have proved their value in practically every walk of life. We are becoming convinced that the sure road to national prosperity and security, to world peace, and to higher standards of living for the entire world is to be found in research. We dare not lag behind other nations in scientific discoveries and their practical application to our daily lives. Hence we are vastly more concerned with what is going on in laboratories, in pilot plants, in the factory, the field, and the market place, and with the nature of the social, political, and economic climate in which science and industry are carried on than were our fathers seventy years ago.

There is no denying the fact that this climate is different from that which prevailed during the closing years of the nineteenth century, which was so favorable to the scientific and industrial development in which Edison took part. During the lifetime of men now in their maturity the industrial economy of the Western World has come of age. Social, economic, political, and moral problems of this economy, which is based on applied science, have become acute. Two world wars, a major depression, and the conflict of divergent and changing political philosophies have confused, complicated, and intensified these problems.

It is apparent that the scientific and economic developments of atomic energy will not take place, for the time being at least, in the same atmosphere of free scientific research and free industrial enterprise that was characteristic of Edison's age. Scientists, engineers, and businessmen regret this hard fact about the Atomic Age, and it is only fair to say that many persons officially charged with responsibilities under the Atomic Energy Act of 1946 are equally concerned.

Regardless of changed conditions, the essential facts remain. The past has demonstrated how powerful a stimulus to material welfare and progress applied science can be. Frames of reference of the social, economic, and political which will influence further material progress have changed and are changing. As in all evolutionary processes, survival and improvement depend on adaptability. It is the duty of the engineer as a good citizen and an objective applied scientist to face these facts and to lend his active and intelligent support to wise solution of the problems that confront the Atomic Age.

In the March issue of MECHANICAL ENGINEERING was published the report to the U. S. Atomic Energy Commission submitted on Dec. 15, 1948, by the Industrial Advisory Group. In its report the Industrial Advisory Group confirmed the opinion of the Commission in establishing it, that "unless the initiative, the technical skills, and the managerial ability of American industry are brought to bear with maximum effect on the problems of atomic-energy development, the people of the United States will not realize the full benefits of this new field of endeavor." The Group discovered "an unmistakable need for greatly expanded participation by industry in atomic-energy development" and mentioned specifically the chemical, petroleum, power, heat-transfer equipment, metallurgical, and instrument industries. It expressed the opinion that "today the central difficulty in getting a broad industrial attack on the problem of atomic energy is the fact that industry has no way of determining whether important opportunities in fact exist in which to take part." Recognizing the need for a considerable degree of secrecy in the interests of national security under current international conditions, the Group offered a number of recommendations relating to increasing contacts between industry and the Commission's field of development and to the declassification and publication of nonsecret information in the Commission's files.

Appointment of a group of editors to advise the Commission on the declassification and publication of nonsecret material is noted in an announcement on page 871 of this issue of MECHANICAL ENGINEERING. This group met in September and its work is under way. The results in published material of value to engineers cannot be assessed at this time, but at least a start has been made on adopting one of the recommendations of the Industrial Advisory Group.

A considerable volume of material has been or is being published, although more of it lies in the fields of science than in the fields of industry. The reports of the Commission bear impressive evidence of this fact. The need for secrecy will be generally admitted, although opinions will differ as to what should be and what should not be made public information. The question: "Is it of greater value to American industry than to a rival nation?" is easier to ask than to answer. The policy of declassifying documents only on request explains why science materials released exceed industrial materials, because the scientist has an urge to publish, to enhance his personal reputation that is stronger than most engineers feel. The relatively few refusals to declassify a document indicate a probably high percentage of declassifiable material. The relatively few persons who have access to secret material limits the number who know of its existence and significance, and hence the number who are in a position to request declassification. The routine involved in declassification is strict and likely to discourage all but the persistent. In addition to all of these extraordinary considerations, it must be remembered that the Commission, its contractors, and the personnel of both live in an atmosphere in which it is easier and safer to err on the side of releasing too little rather than too much information. The mere listing of such factors as the foregoing is enough to suggest the conditions that scientists, engineers, and businessmen face in the development of the Atomic Age as contrasted with those which prevailed before the war.

The dilemma of the Atomic Age is to maintain the essential freedoms of scientific discovery, engineering development, and industrial enterprise without endangering the national security in a world where the state exercises an increasing degree of control on behalf of the public welfare.

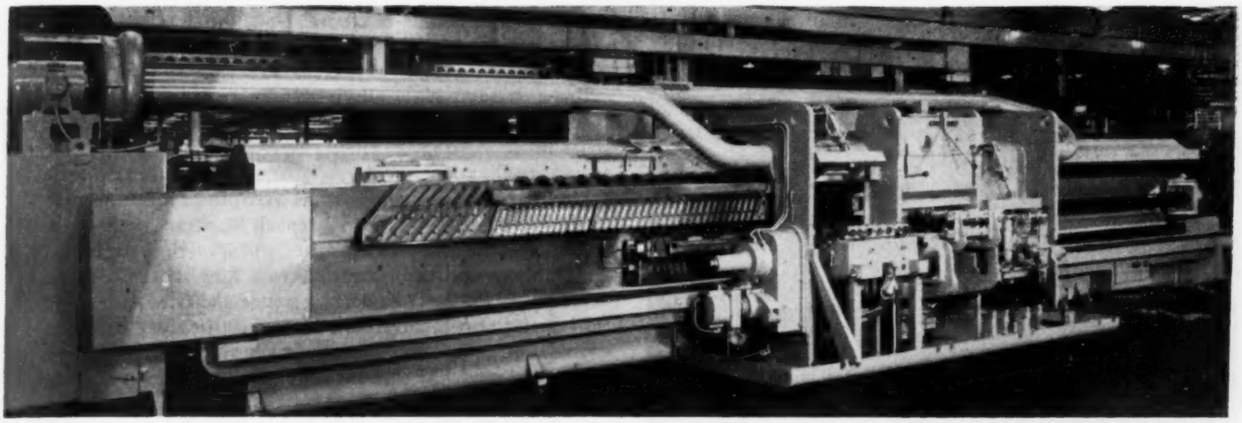

FIG. 1 SPECIAL HORIZONTAL BROACHING MACHINE FOR BROACHING TOP, BOTTOM, MANIFOLD SIDE, AND VALVE-CHAMBER-COVER SIDE ON VALVE-IN-HEAD CYLINDER HEAD

ENGINEERING *for* PRODUCTION

By CARL M. BEACH

ASSISTANT SALES MANAGER, CINCINNATI MILLING AND GRINDING MACHINES, INC., CINCINNATI, OHIO

TWENTY-FIVE to thirty years ago the machine-tool industry supplied its customers almost exclusively with standard machines made from standard sales-catalogue specifications. In turn, the customer who purchased these machines designed and made his own jigs and fixtures, supplied the cutters he thought were necessary, and figured out his complete production problem. As the years have passed, the job of engineering the proper tooling for customers' jobs has fallen more and more upon the shoulders of the machine-tool builder. It has therefore become necessary in most machine-tool plants to have a large staff of production-minded engineers with a practical background and engineering knowledge. Some production problems have been solved by the design of special tooling for use with standard machines, while the machining of other parts, especially in the high production quantities, has involved completely special machines, tailored to perform machining operations on one kind or several different parts.

LOW-PRODUCTION MILLING OF CYLINDER HEADS

A foreign builder of automobiles wanted to machine the top, bottom, manifold side, valve-chamber-cover side, and one end on the cylinder head for a six-cylinder valve-in-head engine. The production requirements on these cylinder heads were exceedingly low and the total requirements were for only three complete cylinder heads per hour. To accomplish the required result, it was possible to use a standard duplex milling machine with special fixtures to hold five different heads in the proper position to present all five surfaces to the two milling cutters.

On this job, the stock removal varied from $^1/_8$ in. to $^3/_{16}$ in. per surface, and it was possible to use high-speed-steel milling cutters having 16 teeth, using a feed rate of $8^1/_2$ ipm. A total of $3^3/_4$ complete cylinder heads were produced per hour at 85 per cent efficiency. The maximum horsepower for this cut was 8 hp. The cutters ran at 100 fpm cut speed. The floor space required for this machine is 180 sq ft.

The cylinder head for this foreign car builder was almost identical to a cylinder head used in this country, and whereas production requirements in the foreign company were three cylinder heads per hour, the requirements in this country were 150 cylinder heads per hour.

BROACHING VALVE-IN-HEAD CYLINDER HEADS

To do this high productive job, several horizontal broaching machines were supplied as shown in Fig. 1. The top, bottom, manifold side, and valve-chamber-cover side were surface-broached at the rate of 63 cylinder heads per hour at 85 per cent efficiency per machine, obtaining a fine finish, a flatness of 0.0015 in., parallelism of 0.002 in., and squareness of 0.002 in. The broaching machine stroke was 15.1 ft at a rate of 45 fpm. This was done with the expenditure of 103 hp. One of these machines requires a total of 375 sq ft of floor space.

The machine consists of a 36-ft-long welded bed, with hardened and ground steel ways, on the front of which is mounted a single ram carrying two rows of broaching tools. The upper row of tools broaches the bottom and the manifold surface of the cylinder head with the workpiece located in the left-hand fixture while the ram is moving from left to right. The lower row of broaching tools broaches the top and valve-cover surface while the ram is moving from right to left and with the workpiece located in the right-hand fixture.

The workpiece progresses from right to left on a conveyer which lines up with the right-hand fixture when in the loading position as shown in Fig. 2. The fresh workpiece is shown in the right-hand fixture with a second workpiece having been shifted from the right-hand fixture into the roll-over device located between the two fixtures. The left-hand fixture carries a workpiece on which the top and valve-cover surfaces have already been broached. The workpiece is then located from

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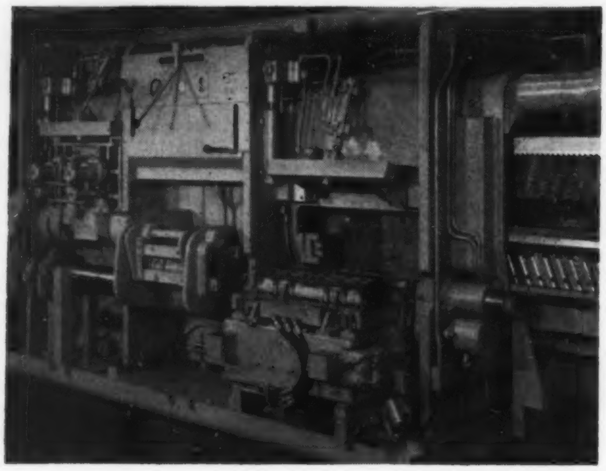

FIG. 2 CLOSE-UP VIEW OF CYLINDER-HEAD BROACHING FIXTURES WITH FIRST OPERATION FIXTURE IN LOADING POSITION

has been supplied two special "mill-broach machines." A third machine of this type is now being built for the same company. This company felt that the cast iron in their cylinder heads, which Brinells at about 240, might present cutting-tool problems when broaching, due to possible hard spots in the castings. The mill-broach machine was designed to remove the rough stock, scale, and hard spots using a milling cutter. A final finish and flatness were obtained with broaching tools. Fig. 3 shows the mill-broach machine, made of welded construction, employing an entirely new method for combining the hogging ability of a milling machine with the speed and accuracy of a broach, thus saving time and floor space. Rough mill and finish-broach cuts are taken on four sides of the cylinder head in one pass at a rate of 50 cylinder heads per hour at 85 per cent efficiency.

Motors totaling 75 hp operate at a maximum efficiency at all times, driving two demountable two-spindle carriers for the milling operation and moving the ram at an increased speed during the broaching cycle. Two additional motors, one $7^1/_2$ hp and one $^1/_4$ hp, operate fixtures and provide correct lubrication to moving members of the broach.

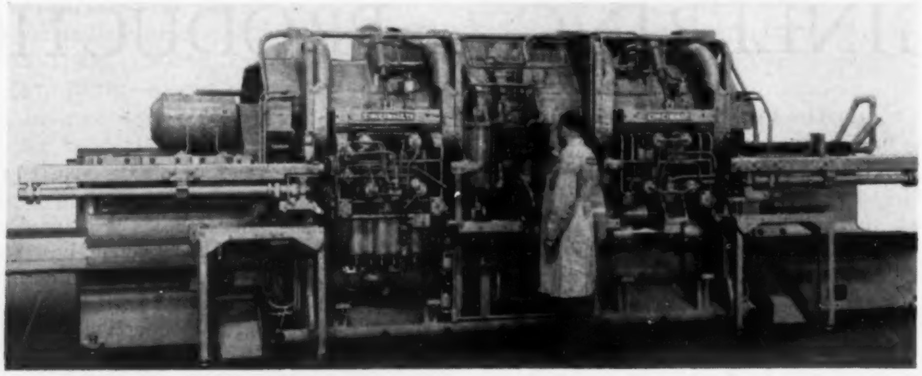

FIG. 3 MILL BROACH FOR MACHINING TOP, BOTTOM, MANIFOLD SIDE, AND VALVE-CHAMBER-COVER SIDE ON VALVE-IN-HEAD CYLINDER HEAD

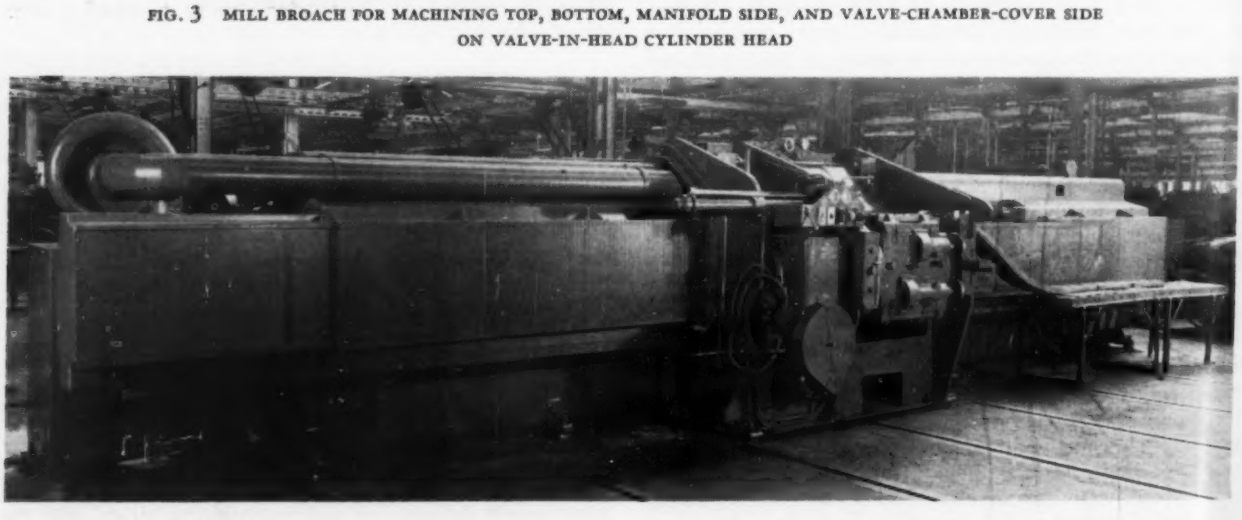

FIG. 4 HORIZONTAL BROACHING MACHINE FOR BROACHING BOLT BOSS SIDE AND CYLINDER HEAD JOINT SURFACE ON L-HEAD CYLINDER HEAD

these finished surfaces when broaching the bottom and manifold surface using the top row of broaching tools. The left-hand fixture, as can be seen, is in the broaching position.

MILL-BROACHING MACHINE FOR VALVE-IN-HEAD CYLINDER HEADS

Within the last two years another automobile manufacturer

Stock removal is $^1/_8$ in. to $^3/_{16}$ in. on all surfaces of cast iron at 240 Brinell. The rough stock is removed by tungsten-carbide milling cutters revolving at 250 fpm cut speed.

During the first half of the cycle the machine rough-mills at 60 ipm. In the second half of the cycle the ram speed increases and the cylinder heads are broached at 40 fpm. The

ram then returns at 30 fpm as the work is loaded, and removed by hydraulic transfer cylinders in the following manner: The finished head is transferred to the conveyer, the previously rough-milled head is moved into a roll-over device and one from the roll-over device is automatically repositioned, loaded, and clamped in the second operation fixture. Another head is transferred from conveyer line, loaded, and clamped in the first operation fixture. The entire procedure is automatic, but individual units may be operated independently when desired.

Adequate safety features are provided that not only protect the operator from injury but safeguard the machine and workpiece from damage due to carelessness or negligent operation.

This two-machines-in-one idea means a considerable saving in floor space. The floor space required is 216 sq ft and the height is $7^1/_4$ ft. The motors, pumps, etc. are easily accessible from the rear without disturbing the operator.

BROACHING L-HEAD CYLINDER HEADS

Another example of how the machine-tool builder is called upon to make machine tools to fit the customer's needs is the equipment for L-head cylinder heads. Fig. 4 shows the general view of the equipment for broaching the bolt boss surface and the cylinder-head joint surface. Since an L-head cylinder head has only two surfaces to be machined, the equipment must be of a different nature from that for broaching the valve-in-head cylinder head. Fig. 4 shows the work-holding fixture in the position where the ram returns past the idle section of the fixture. While the ram is returning from left to right, the completely finished workpiece is automatically moved down the incline chute and another workpiece broached on the bolt boss surface only is moved into the transfer cradle, as shown in Fig. 5. This shows the fixture in position for loading a completely rough cylinder head in the lower portion of the fixture and then locating from foundry locating spots in the combustion chambers. In the upper portion of the fixture is loaded a workpiece which has been broached on the bolt boss sides and which has just come from the swinging loading cradle as shown on the right-hand side of the fixture. While this loading is taking place, two other cylinder heads, 180 deg away from those that can be seen, are being surfaced-broached by the broaching ram moving from right to left. This ram carries two rows of broaching tools, one row for the bolt boss surface and the other row for the cylinder-head contact surface.

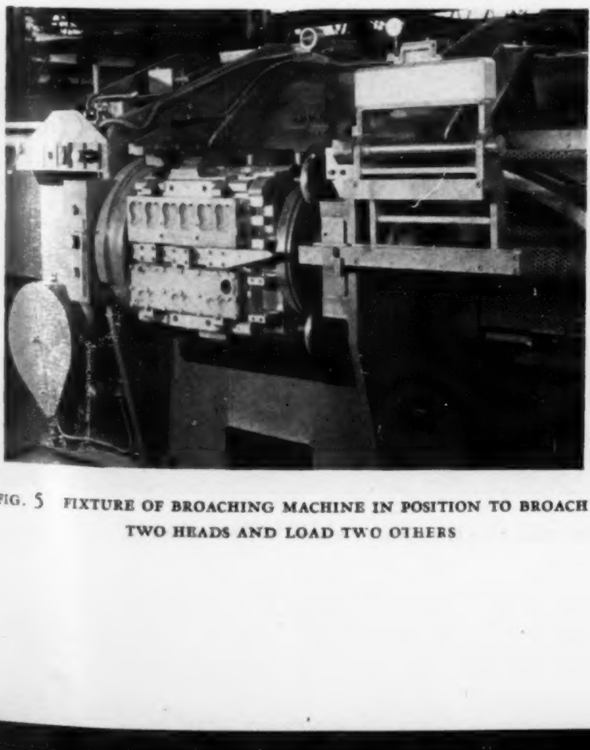

FIG. 5 FIXTURE OF BROACHING MACHINE IN POSITION TO BROACH TWO HEADS AND LOAD TWO OTHERS

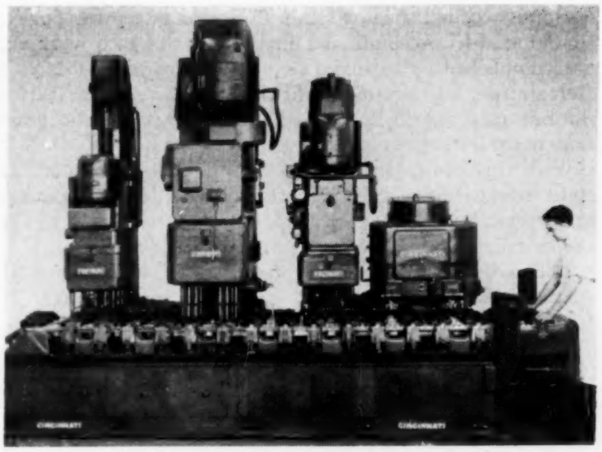

FIG. 6 TRANSFER-TYPE MACHINE TO MILL, DRILL, COUNTERBORE, AND TAP V-8 CYLINDER HEADS

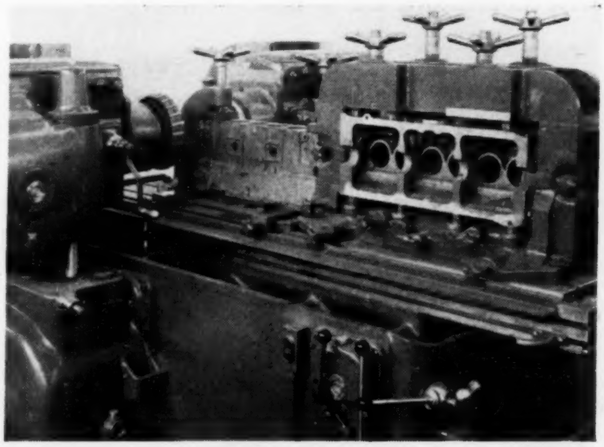

FIG. 7 LOW-PRODUCTION SETUP FOR DUPLEX MILLING TOP, BOTTOM, AND MANIFOLD SIDES ON CYLINDER BLOCK

On this type of machine, removing $^1/_8$ in. to $^3/_{16}$ in. stock per surface with a forward ram speed of 40.2 fpm and a return ram speed of $66^1/_2$ fpm, 68 complete cylinder heads per hour at 85 per cent efficiency are obtained. The total horsepower required for this machine, including that for the operation of the dust-exhaust system, was 135 hp; and the machine weighs approximately 89,000 lb.

COMBINING OPERATIONS WHEN MACHINING CYLINDER HEADS

In the high-production field, engineering for production often leads to the consideration of combining the various types of operations, such as milling, drilling, counterboring, tapping, etc. A good example is shown in Fig. 6 of a transfer-type machine, three of which were made for the builder of V-8 engines. The series of operations are as follows: rough and finish-mill the water outlet pads, mill a $1^3/_8$-in-diam spot face on a 5-degree angle, mill two coil-mounting pads and bolt boss between them, drill and tap 8 holes, and spot-face 35 holes.

This equipment enables the operator to place one right-hand and one left-hand cylinder head in the machine at one end and then have these workpieces automatically progress through the various milling, drilling, spot-facing, and tapping units, and come out at the other end finished.

Transfer movement of these cylinder heads from station to

station is accomplished by means of a series of transfer dogs on a moving rail. Accurate and final location of each workpiece is accomplished by means of two dowel pins being located at each station. The clamping of the workpiece in the various stations is accomplished automatically by hydraulic power as is the transfer movement of the workpiece.

With this equipment, the operator is able to produce 120 right-hand cylinder heads 120 left-hand cylinder heads per hour at 85 per cent efficiency, with his only duties being to load the cylinder heads at the starting end of the machine.

The milling feed rate is approximately 40 ipm and the cutting speed of the milling cutters is approximately 280 fpm.

MACHINING OF CYLINDER BLOCKS

Cylinder blocks are, in general, of two classes: straight-in line, or V-type.

Fig. 7 shows the machining of the cylinder block for the same valve-in-head cylinder head mentioned earlier. A standard duplex machine with two fixtures was used. The first fixture holds the cylinder block for the milling of the valve-chamber cover and the fixture on the right is arranged to hold the cylinder block so that the top and bottom surfaces can be milled. With a stock removal of $^1/_8$ in. to $^3/_{16}$ in. per surface, three surfaces were milled using a feed rate of $7^1/_4$ ipm. Production was 4.4 cylinder blocks per hour at 85 per cent efficiency, with a total horsepower consumption of $8^1/_2$. Stellite cutters, a $12^1/_2$-in-diam face mill with 24 teeth, and an 8-in-diam face mill with 16 teeth, operating with a milling speed of 161 fpm, were used.

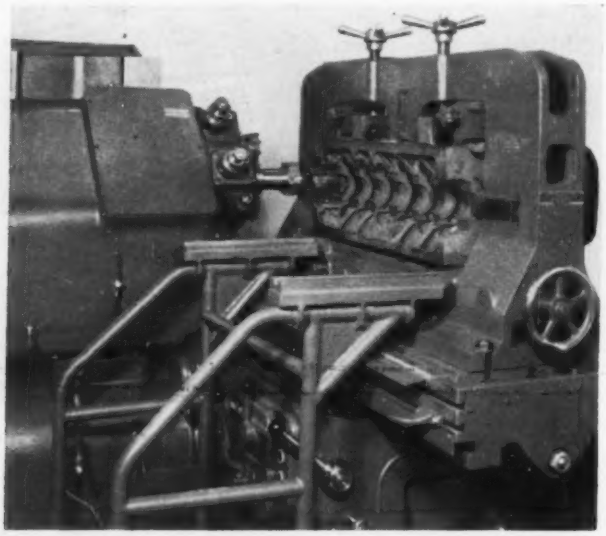

FIG. 8 MEDIUM-PRODUCTION SETUP FOR MILLING TOP, BOTTOM, AND BEARING LOCKS ON CYLINDER BLOCK ON DUPLEX MILLING MACHINE

MEDIUM PRODUCTION OF CYLINDER BLOCKS

Another example of special equipment is a machine for milling the top and bottom, and rough-milling the bearing lock of a truck cylinder block. Fig. 8 shows a standard Hydromatic with a special three-spindle carrier for the milling of the bottom or pan rail surface and the rough-milling of the bearing locks. On the opposite side of the machine a single standard spindle carrier with a large flywheel in back of the face mill is supplied for the milling of the top surface of the cylinder block. Twenty-four cylinder blocks per hour were obtained at 85 per cent efficiency with tungsten-carbide-tipped shell end mills and face mills operating with a cutting speed of 270 fpm and using an average table feed rate of 20 ipm.

BROACHING OF CYLINDER BLOCKS

In contrast, Fig. 9 shows a general view of a horizontal broaching machine for rough- and finish-broaching the bottom or pan rail surface and rough-broaching the half bore of a cylinder block in the right-hand fixture, and rough and finish-broaching the top and valve-chamber cover of the same cylinder block in the left-hand fixture. Here again, the block approaches the machine coming from right to left and is automatically moved from the conveyer line into the right-hand fixture while the broaching operation is taking place at the left-hand fixture. When the broaching cut has been completed in the left-hand fixture, the left-hand fixture indexes down to the loading position and the right-hand fixture indexes up into the broaching position. The machine is a two-way cycle machine with the tools for the bottom and half bore being on the lower part of the ram and operating while the ram is moving from right to left, while the tools for the top and manifold or valve-chamber cover are located on the top of the ram and operate on the workpiece in the left-hand fixture with the ram moving from left to right.

With this machine broaching at a rate of 46 fpm with high-speed-steel inserts and tungsten-carbide finishing inserts, it was possible to obtain 55 complete cylinder blocks per hour at 85 per cent efficiency.

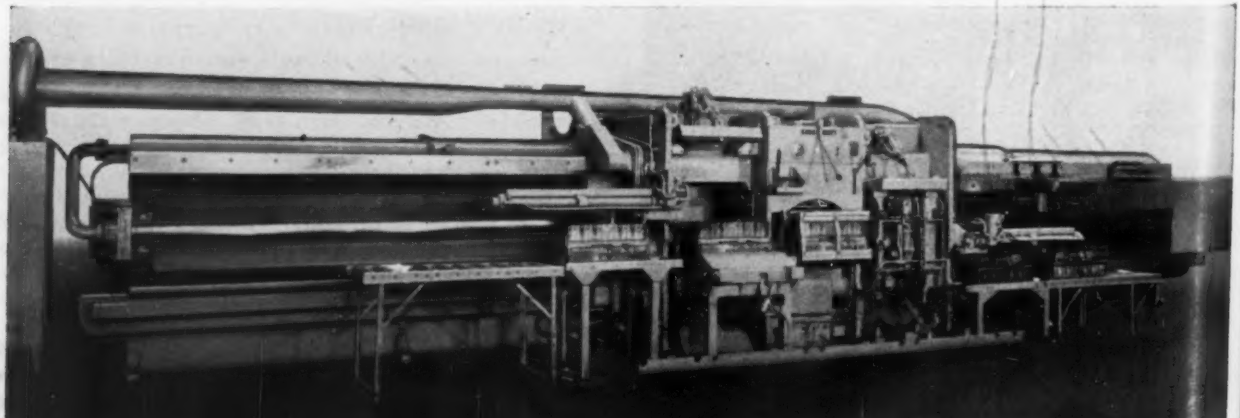

FIG. 9 MACHINE FOR BROACHING BOTTOM, HALF BORE, TOP, AND MANIFOLD FACE ON CYLINDER BLOCK

The machine covers approximately 370 sq ft of floor area and uses approximately 160 hp.

MILLING A WOODRUFF KEYWAY

The foregoing examples of engineering for production have been applied to the automotive industry. Now consider a simple job, such as milling a Woodruff keyway in a shaft. The standard method consists of using a simple shaft jig with one or two simple clamps operated by a loose wrench and to mill the Woodruff keyway into the shaft by means of raising and lowering the knee of a standard knee-and-column-type milling machine. However, it is sometimes desirable to do this same operation at a high production rate.

Fig. 10 shows a general view of a production-type milling machine used for milling a Woodruff keyway in a similar shaft. The operator's only function is to keep the trough full of shafts which are to be milled. During each cycle of the machine, the spindle carrier rises to its top position and the shaft that has previously been milled is automatically diverted down the lower chute. As soon as the shaft has passed to the lower chute, an escapement mechanism allows one shaft from the upper chute to roll into place in the vees of the fixture. As the spindle carrier feeds the cutter to its milling position, the two spring-loaded clamps, one on either side of the escapement mechanism, clamp the workpiece ahead of the time when the cutter actually starts to mill the keyway.

Using this type of equipment, it was possible to mill a $^{5}/_{8}$-in-diam Woodruff keyway in 250 shafts per hour at 80 per cent efficiency.

AUTOMATIC CENTERLESS GRINDING

Another problem is the building of machine tools which provide increased safety for the operator and are more productive yet less fatiguing to the operator.

Less and less connecting-rod bolts were being ground in an eight-hour day, using hand-operated centerless grinders. This raised the problem of grinding connecting-rod bolts using an automatic cycle of operation. The normal way for these parts to be ground in the past has been for the operator to load the pieces one by one by hand. Each piece required the operator to pull down the infeed lever, grind the piece, and as the infeed lever was moved back to its original position, the piece would be ejected automatically into a pan at the front of the machine.

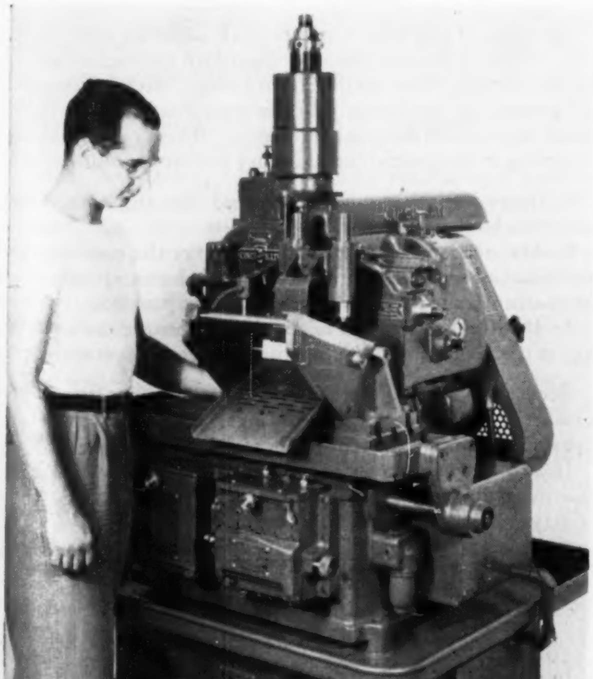

FIG. 10 AUTOMATIC MILLER FOR CUTTING WOODRUFF KEYWAY IN SHAFTS

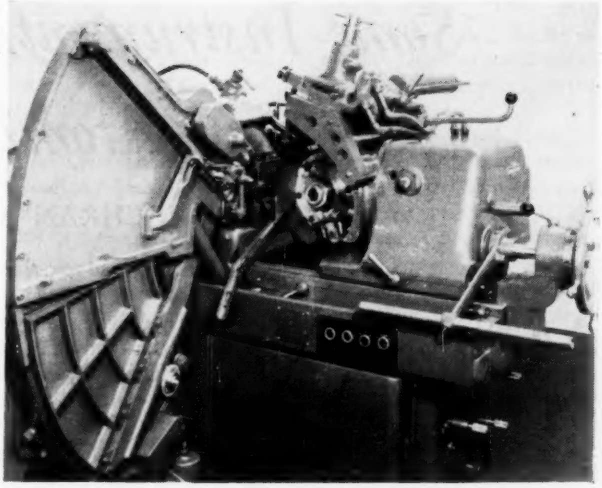

FIG. 11 AUTOMATIC PRODUCTION GRINDING CONNECTING-ROD BOLTS

Fig. 11 shows a setup whereby the operator's duties are confined to keeping the hopper, shown on the left-hand side of the centerless grinder, full of connecting-rod bolts. The regulating wheel, shown in the center of the figure, is dressed or trued to a cammed shape. When the low spot of the cammed shape comes around to the position opposite the work-support blade of the machine, the hopper loads a piece in between the low spot of the regulating wheel and the grinding wheel. Continued rotation of the regulating wheel, which is trued to the cammed shape, pushes the workpiece against the grinding wheel and the rise in the cammed shape of the regulating wheel is equal to the total amount of stock removal to be removed from the workpiece. When the top of the cam rise has been reached, there is a dwell or a radial line on the regulating wheel which allows the workpiece to revolve several times to be sure to clean up. Then the workpiece will be ejected in another low spot in the regulating wheel. This means that for every revolution of the regulating wheel one complete workpiece is ground. In the case of the connecting-rod bolt the machine is set at 16 rpm, which means that 16 connecting-rod bolts are produced every minute and the operator's only function is to keep the hopper loaded.

CONCLUSION

More and more as time goes on industry asks for closer limits and better finish which calls for more precision machine tools. It is desirable to have machine tools as free as possible from maintenance and down time with the various mechanical units being easily accessible for repair when needed. Materials are ever-changing, which calls for a wider range of feeds and speeds and, in general, greater horsepower.

The machine-tool builder therefore must analyze each job thoroughly, approach the problem from many different methods and select the one way which will provide the most returns and render the greatest service to the user, provide safety to the operator, and reduce operator fatigue to a minimum.

Some Instrumentation Requirements in an Atomic Power Plant

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Many unusual problems are encountered in applying instrumentation to an atomic power plant, for which, as yet, there are no demonstrated solutions. Hence there is opportunity for suggestions from engineers which may contribute to the development.

The present discussion is limited to consideration of detecting elements. Requirements for automatic or self-regulating controls, which are necessary in certain of the applications, will not be covered in this paper.

THE ATOMIC POWER PLANT

The atomic power plant to be constructed for the Atomic Energy Commission at the Knolls Atomic Power Laboratory in Schenectady probably will be the first to generate useful electric power in more than token amounts. This is an experimental plant whose purpose is to investigate power production on a practical scale. It will also be used to investigate the possibilities of breeding, that is, the simultaneous production of new nuclear fuel at a rate greater than the fuel consumption. This plant employs liquid-metal reactor coolant and steam - turbo-electric power-generation equipment. The discussion presented here is related to such a plant as shown schematically in Fig. 1.

FIG. 1 SCHEMATIC DIAGRAM OF ATOMIC POWER PLANT

The reactor is an assembly consisting of jacketed nuclear-fuel elements, control elements, moderating material, and reflecting material, all supported and positioned in a structural matrix. The liquid-metal coolant is pumped through channels in the reactor core, where it receives heat from the fuel elements. Leaving the reactor, the coolant passes through heat exchangers where it gives up heat to evaporate and superheat steam. The steam drives a turbogenerator to generate electric power.

The heat-generating nuclear reaction in the reactor core causes tremendous radioactivity which must be confined by an absorbing shield. The liquid-metal coolant passing through the reactor core becomes radioactive because of its exposure to neutron flux. Thus the piping, pumps, heat exchangers, and storage tanks which carry the radioactive coolant also must be shielded, although to a lesser extent than the reactor core. The radioactivity of the coolant does not cause radioactivity in the water and steam passing through the heat exchangers; hence it is not necessary to shield the steam and water piping and equipment in the power plant.

The reactor coolant leaves the reactor at temperatures high enough to permit an efficient steam cycle. Liquid metals have relatively low vapor pressures, however, and can be maintained in the liquid phase at pressures of a few atmospheres throughout the circuit. Hot liquid metals oxidize readily in contact with air, forming compounds harmful to operation as a coolant. To prevent oxidation, it is necessary to maintain a blanket of inert gas over free surfaces of liquid metal wherever they occur.

There are remotely controlled mechanisms for actuating control elements, for removing spent fuel elements, and for inserting fresh ones. The spent fuel elements are intensely radioactive, and must be transported, stored, and processed in shielded spaces by means of remotely controlled machinery.

INSTRUMENT FUNCTIONS

Operation of this plant requires much elaborate instrumentation. Most of the instruments are standard commercial devices as, for example, those on the steam turbine, electric-generating equipment, and auxiliaries. Others must meet unusual requirements, and special designs are required. These can be classified according to the general function they perform as follows:

1 Operation: Instruments required for the control and safety of the plant operation.

2 Maintenance: Instruments to observe the condition and and behavior of the reactor structure, fuel elements, coolant and blanketing gas as the operation of the plant proceeds.

3 Health: Instruments required to monitor radiation leakage in the plant to insure protection of operating personnel.

For plant operation there must be instruments to detect these quantities. Where possible a single instrument should be capable of covering the range indicated in Table 1.

Health instruments must detect alpha, beta, gamma, and neutron radiation in exceedingly minute quantities, wherever it may leak through shielding or emanate from radioactive objects or from surfaces contaminated by radioactive substance. There is considerable published information about these instruments, so this paper will not elaborate further on them.[3]

GENERAL DESIGN REQUIREMENTS

In addition to requisite accuracy and sensitivity, a number of detecting devices in atomic power plants must meet require-

[1] Mem. ASME.

[2] Operated by the Research Laboratory, General Electric Company for the Atomic Energy Commission.

Contributed by the Industrial Instruments and Regulators Division and presented at the Semi-Annual Meeting, San Francisco, Calif., June 27–July 1, 1949, of The American Society of Mechanical Engineers.

[3] "Physical and Medical Aspects of Radiation," by L. L. German and H. M. Rozendaal, *Electrical Engineering*, vol. 67, 1948, pp. 884–890.

TABLE 1 INSTRUMENT RANGE

	Range
Neutron flux density in or near reactor core	10^7 fold
Control-element position	Within 0.005 in. over many feet
Reactor coolant temperatures	200 F to 1200 F
Reactor coolant pressures	—10 psi to 100 psi
Reactor coolant flow	0 to thousands of gpm
Coolant-liquid level	———
Blanket-gas temperature	200 F to 1200 F
Blanket-gas pressure	1 mm Hg abs to 100 psi

To assist and guide maintenance, the following quantities must be detected or observed:

Fuel-element temperatures	200 F to 1200 F
Internal pressures in reactor parts	A few atmospheres
Fuel-element rupture	Traces of fission products and fuel released into coolant stream
Core structure and fuel-element distortions	A few mils
Chemical contamination of reactor coolant	Very small amounts
Fission-product (radioactive) contamination of coolant	Traces of neutron flux in coolant remote from reactor
Chemical contamination of blanket gas	Very small amounts
Fission-product contamination of blanket gas	Traces of radioactivity in gas withdrawn from radioactive zone
Fuel-handling manipulation	Remote visual inspection of motions of a few hundredths of an inch to several feet
Location of stored spent-fuel elements	A fraction of an inch in channels and passageways several hundred feet long
Leakage of coolant	1 cc and up

ments not found in conventional power-plant applications. These requirements arise from the radioactivity of the reactor and coolant and the shielding surrounding them. Typically, the shield may be several feet of concrete. The structure, equipment, and instruments within this radioactive zone are subjected to radiation of varying intensity depending on location. Some of these become permanently radioactive as a result of this exposure.

Some of the unusual requirements of instrumentation in the radioactive zone are as follows:

Extreme Dependability. It is essential that the nuclear reaction remain under control at all times. This is necessary to protect the reactor and associated equipment from damage, and to protect operating personnel in the plant from exposure to radiation from radioactive materials from the reactor. It is important here to note that, because of important differences in construction, it is not possible for a nuclear reactor in an atomic power plant to explode like an atomic bomb.

However, extremely dependable operating instruments, backed up by adequate safety controls, must be provided. Safety controls have been designed to stop the nuclear reaction. There is nothing about the nuclear reactor that corresponds to the safety valve of the steam boiler in a conventional power plant. In such a plant when there is a sudden increase in the rate of heat generation, or, as is more likely, a sudden decrease in heat absorption by the load, the extra energy in the boiler may be dissipated by blowing the safety valve. The nuclear reactor, however, has a definitely limited capacity for absorbing or dissipating extra energy. The instruments must sense abnormal conditions of heat generation or heat removal quickly and accurately to initiate appropriate action of the controls.

Of course no single instrument bears the entire responsibility for the safety of the plant. There are a multiplicity of detecting devices and a number of independent safety controls. Since an exceedingly high order of safety is to be achieved, these many instruments and controls are designed to "fail safe;" so, an instrument failure shuts down the plant. Uninterrupted operation of the plant, therefore, requires reliability of all instruments and circuits.

Remote Maintenance. It is not possible to perform direct inspection and maintenance work on the detecting devices within the radioactive zone. They must be designed so that they can be checked and calibrated remotely, where this is necessary.

When a failure occurs, it may be necessary, because of radioactivity at the location of the device, to remove and replace it by means of remotely operated equipment. If the device has become radioactive in service, it usually cannot be repaired after removal, but must be replaced with a new unit.

Where the detecting elements are very difficult to remove or are completely inaccessible, stand-by detecting elements must be installed at the time of erection.

Neutron and Gamma Radiation. Pressure, temperature, and flow detectors must function correctly in the presence of tremendous radiation. Continued exposure to radiation must not cause such physical deterioration of the device as to change its performance in a way that cannot be determined and compensated for.

Devices to detect chemical contamination of the coolant must function in spite of the radioactivity of the coolant.

Absolute Leaktightness. Detecting elements exposed to the coolant or blanket gas must be absolutely leaktight. The escape of even minute quantities of radioactive coolant or of blanket gas which might contain gaseous fission products might require that the plant be shut down and personnel evacuated until the leak could be located and repaired.

Long Service. Because of the extreme difficulty and expense of replacing faulty detecting elements, long operating life is much more important in these applications than is usually the case. There is great incentive to develop long-lived devices, and there is frequent justification for using more expensive devices to insure long service. A few situations exist where, once the reactor has been operated, detecting elements become absolutely inaccessible. Obviously, such arrangements are undesirable, and much effort must be devoted to designing systems which avoid them.

INSTRUMENT APPLICATIONS

As previously stated, successfully demonstrated devices to meet these requirements have not as yet been developed for all the applications listed. Some of the devices upon which work is being conducted will be discussed.

Neutron Flux. Neutrons can be detected by measuring alpha radiation induced by their capture in boron. This is by means of ion chambers coated with boron or filled with boron-trifluoride gas. Boron atoms present a relatively large target for neutrons, and, upon capture, emit alpha particles which are powerfully ionizing in gas. Thus the capture of neutrons causes ion-current pulses between electrodes of the ion chamber which are readily discriminated from ionization caused by gamma radiation.

This discrimination is necessary because power generation in the reactor is directly related to neutron flux density, but not to the level of gamma radiation.

In operating the reactor, it is necessary to detect small changes in neutron flux over a range of 10^6 or 10^7 in intensity. Ion currents in the order of micro-microamperes must be measured. To extend the range, several ion chambers may be used having different ranges by virtue of their location with respect to the reactor core.

A further requirement of the neutron-detecting systems is that they have an extremely rapid response time, in the order of

milliseconds. This speed is necessary to actuate control elements or safety elements to compensate for sudden changes in reactivity in the reactor.

The principal limitations as to range and speed of neutron detection lie not in the ion chambers but in the associated circuits and relays. Present high-sensitivity amplifiers have high input impedance which imposes difficulties as to electrically insulating and shielding the leads to the detector so as to exclude spurious electric signals.

Finally, the neutron detectors must operate accurately and reliably at the high temperatures prevailing around the reactor core. This is a new requirement not found in the neutron detectors used in health physics work or in controlling low-temperature reactors such as those at Hanford which do not generate useful power.

Pressure. Measurement of pressure of the reactor coolant by means of Bourdon-type pressure gages with electrical telemetering is being considered. A gage fluid must be selected which will not suffer deterioration because of radiation exposure, and which will not contaminate the liquid-metal coolant. If blanket gas is used in the tube, there must be provision to insure its presence in adequate volume, regardless of pressure variations, entrainment, or dissolution in the coolant. Materials of the tubes must be corrosion-resistant, and must maintain their elastic properties at high temperature.

Another type of pressure detector being investigated involves a thin diaphragm exposed to the coolant on one side and maintained in null position by a gas pressure on the other side. The balancing gas pressure may be measured remotely and the null position maintained by a needle valve actuated by the diaphragm so as to control the gas supply. This detector is relatively accurate and simple, but the thin diaphragm is thought to be a particularly vulnerable part of the coolant system. The diaphragm must be protected from overstress due to pressure surges, and there must be provision for stopping the escape of coolant in case of diaphragm failure.

Although there are pressure limits which must not be exceeded for safe operation, the response time of pressure detectors need not be unusually short. Normal operation of the plant does not involve rapid fluctuations in pressure.

Temperature. Temperatures may be measured by means of thermocouples and resistance thermometers. Those measuring coolant temperatures are mounted in wells which must be tight, strong, and corrosion-resistant. Thermal contact with the ambient coolant must be good so that heat generated by absorption of neutrons and gamma rays in the sensitive element will be dissipated to maintain the element at the temperature of the coolant to be measured.

Electrical insulation of thermocouple wires in the radiation zone must be such as to resist damage from neutron and gamma radiation and high temperature. There is evidence that many organic insulations deteriorate rapidly in such environments. It is believed that quartz, glass, or ceramic insulations will give reasonably good service.

Measurements of temperature and pressure in the reactor core and fuel elements are important in determining the allowable power rating and in observing the condition of the reactor, in much the same way that the temperatures and pressures in the combustion chambers of an internal-combustion engine are related to its power rating and condition. Clever means such as temperature-sensitive paints and piezoelectric pressure detectors have been devised for internal-combustion engines, and similarly clever means of detection eventually must be worked out for the reactor.

Flow. Operation of the experimental reactor will involve a wide range of coolant flow rates. This makes it difficult to measure flow with fixed-orifice flowmeters.

Flow of liquid-metal coolant may be measured over a wide range by electromagnetic flowmeters.[4] This type of flowmeter has the great advantage that it does not require penetration of the pipe wall or introduction of fixed or moving devices into the coolant stream.

The electromagnetic flowmeter, Fig. 2, involves a permanent

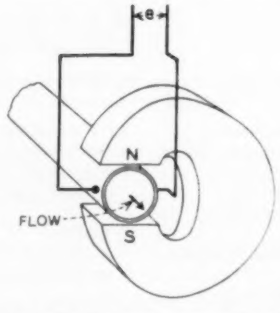

FIG. 2 ELECTROMAGNETIC FLOW DETECTOR

magnet to produce magnetic flux through the liquid metal flowing in the pipe. Motion of the conducting liquid metal in the magnetic field causes an electric potential gradient normal to the magnetic field and direction of flow. This potential is measured by means of electrodes attached to the pipe. For a given magnetic field, the potential measured is proportional to the flow of liquid, provided the flow is only a function of radius in the pipe.

There is considerable practical difficulty in calibrating any type of liquid-metal flowmeter for the large flows and high temperatures encountered in the power plant, so for some time to come the calibration of these meters may be by extrapolation from calibrations of small meters. However, the device has good sensitivity and stability when changes in magnetic field and electrical conductivity due to temperature are taken into account. It is believed that the magnetic field will not be affected appreciably by irradiation of the magnet.

Liquid Level. It is necessary to detect the level of the liquid-metal coolant in storage tanks, surge tanks, and in a number of other locations. Level indicators which involve transmitting motion or force from a float through the wall of the vessel are thought to be of questionable reliability if they involve immersed moving parts, thin diaphragms, or bellows.

Electrical contacts through which the liquid metal closes an electric circuit upon attaining a certain level may be used in some locations. These have the possible difficulty that condensing metal vapor may, in time, short-circuit insulation of the contact. Other means, utilizing electrical properties of the liquid metal, may be developed.

Leak Detection. It is vitally important that leaks in the liquid-metal system be detected and located at their very incipience. Means for doing this usually involve detecting the metal vapor. The mercury-vapor detector[5] used in coal-fired mercury boilers is an example of this type of detection. In the atomic power plant the problem is considerably more difficult in the radioactive zone. It is not possible to locate the leak by inspection, once it has been detected; so there must be compartmentation of the space around the liquid-metal system, and numerous leak detectors to permit localizing the source of trouble.

Optical Systems. There must be optical systems for viewing

(*Continued on page 820*)

[4] "An Alternating Field Induction Flow Meter of High Sensitivity," by Alexander Kolin, *The Review of Scientific Instruments*, vol. 16, May, 1945, pp. 109–116.

[5] "Industrial Mercury Vapor Detector," by T. T. Woodson, *Industrial Medicine*, vol. 10, April, 1941, pp. 22–24.

HUMAN FACTORS *in* DESIGN *of* MANUAL MACHINE CONTROLS

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INTRODUCTION

ONE of the industrial engineer's primary areas of interest is man at work; the work methods he uses, the tools and equipment he uses, the conditions under which he works, his motivation to work, the monotony and fatigue effects of the job, and his part in the social complex of the work situation. This catholic interest has led to many and varied investigations into the factors affecting the work situation. A great deal of attention has been devoted to investigating methods of work and to formulating general principles governing the development of effective working methods. The engineer probably has devoted the greatest amount of attention to this area.

An important factor influencing methods of work is the design of tools, equipment, and machinery provided for the job. With the advanced state of design of machine tools today, it is incongruous to find that many machines are ill-suited to the people who operate them, and are thus the direct cause for ineffective working methods. During the recent war the armed services found that many of their critical devices, while mechanically perfect, were incapable of effective operation by highly skilled individuals. Detailed investigations[2] by industrial psychologists and engineers indicate that the "human factors" in the design and operation of the equipment were overlooked.

Understanding these factors means having a knowledge of the relationship between the worker and the machine he operates. To provide information concerning this relationship, a series of studies is currently in progress at the University of California Industrial Engineering Research Laboratories under the general title, "Human Factors in the Design of Machinery." The purpose of all these studies is to determine fundamental principles and to supply quantitative information which will be of use to the designer. Other data will evaluate specific machine characteristics which affect its operation.

STUDY OF HAND CONTROLS

The purpose of the study reported here was to determine the factors making for optimum control and speed of usage of handwheels, cranks, and crossbars under the condition of application involving single settings of indicators within close tolerance limits. Such conditions of use would be found in setting control devices on many machine tools. Some of this information will aid the designer in deciding upon the location, type, and design of controls to achieve optimum operating conditions.

Scope of the Study. To carry out the purpose of the study, an operation was established, and an experimental work station was built which permitted an operator to set an indicator to a specific position by turning either a handwheel, crank, or crossbar one complete revolution. The following factors were held constant:

1 Contents of the operation.
2 Accuracy requirements of the operation.

The following variables were introduced:

1 Type of control device, i.e., handwheel, crank, or crossbar.
2 Size of control device.
3 Work load, i.e., frictional torque applied to the shaft of the control device.
4 Location of the control device in relation to the operator, both as to height and angle of the axis of the shaft of the control device.

Selection of Subjects. The subjects in the experiment were volunteers from the male population of the university. All were right-handed and had no visual defects nor injuries to their hands or arms. They varied in age from 23 to 27 years with an average of 25 years. Their average height was 5 ft 9 in. and ranged from 5 ft $6^1/_2$ in. to 6 ft 1 in.

Two months prior to the start of the experiment a pilot group was trained in the operation. With the preliminary data collected, a statistical analysis was undertaken to determine the number of subjects that would be required for the experiment. With the magnitude of the differences known and the variation among and within subjects known, a sample size of five subjects was found to give results of sufficient accuracy.

Ten volunteers, whose schedules suited the experiment, were selected and put through the training program. One of these could not continue and so data were collected on the remaining nine. The experimental trials were begun when it became apparent, as a result of examining the learning curves, that each subject had learned the operation.

Operating Equipment. The work station, Fig. 1, was designed to permit rapid interchange of control devices, change in the location of the controls in relation to the operator, and change in the frictional torque applied to the shaft on which the control devices were mounted. Variations in location were made possible by mounting the control shaft on a platform table which could be raised and lowered to predetermined positions and which could be tilted to all of the desired angles ranging from 45 deg below horizontal to vertical. The control shaft was mounted in friction-free roller-bearing pillow blocks. To achieve the desired torques, friction loads were applied to the shaft by adjusting C-clamps around two oak vise jaws surrounding the shaft.

At eye level was mounted a 5-in-diam indicator dial face containing 100 divisions. An indicator hand in the center of the dial face was connected by chain and 1:1 ratio sprockets to the control shaft.

The handwheels were samples furnished by co-operating machine-tool manufacturers, altered to make for easy mounting and then counterbalanced. The nominal sizes (diameters) of the wheels were 3 in., 6 in., 8 in., 10 in., and 16 in. The

[1] Statistical Adviser, Harry M. Hughes, Statistical Laboratory, University of California, Berkeley, Calif.

[2] Refer to the Bibliography at the end of the paper for list of some investigations.

Contributed by the Management Division and presented at the Semi-Annual Meeting, San Francisco, Calif., June 27–July 1, 1949, of The American Society of Mechanical Engineers.

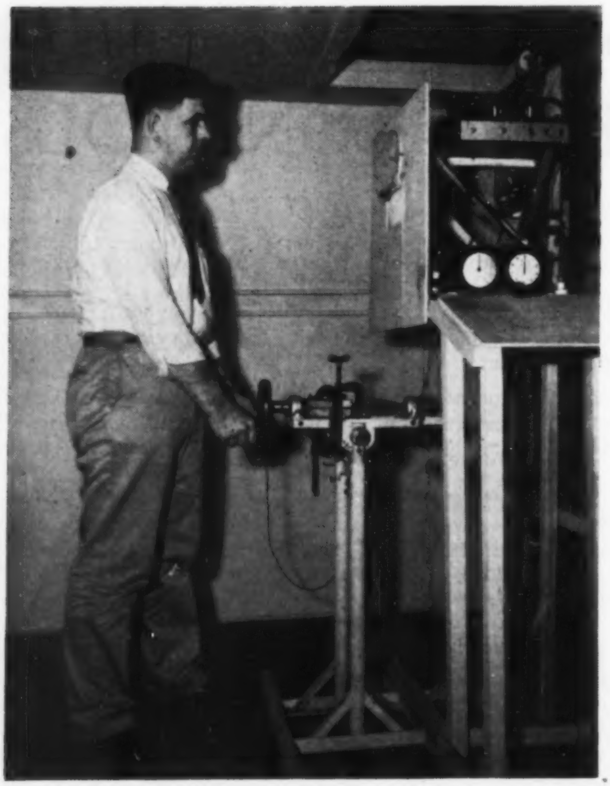

FIG. 1 WORK STATION SHOWING RECORDING EQUIPMENT; 6-IN-DIAM WHEEL AT 36 IN. HEIGHT, HORIZONTAL AXIS

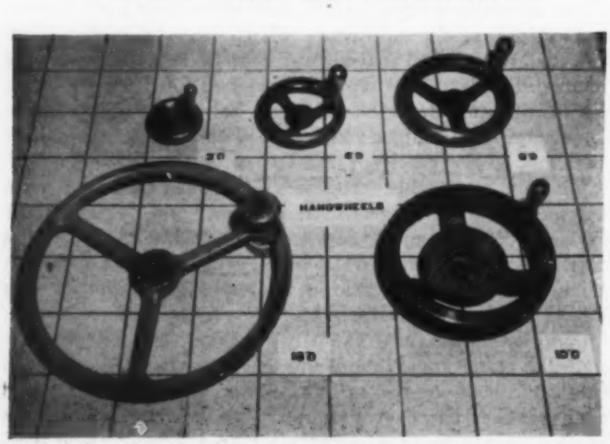

FIG. 2 HANDWHEELS

actual radii as measured were $1^1/_2$ in., $2^1/_2$ in., $3^1/_2$ in., $4^1/_2$ in., and 7 in. The handwheels are shown in Fig. 2.

The cranks were made from $1^1/_4$-in. × $^1/_4$-in. steel with commercial handles of the proper size inserted at the desired distance. The sizes (radii) of the cranks used were $1^1/_2$ in., $2^1/_2$ in., $3^1/_2$ in., $4^1/_2$ in., and $7^1/_2$ in., Fig. 3. These were left unbalanced.

The crossbars constructed for the experiment were counterbalanced, Fig. 4. The two sizes used, $4^1/_2$ in. and $7^1/_2$ in., are measured from the center of the crossbar to the center of knobs on the ends of the bars.

The Operation. Each subject performed the same operation throughout the duration of the experiment with a new variable introduced at the end of each 10 repetitions. To perform the operation, the subject attached a contact lead to his ankle after the experimenter adjusted the apparatus for the variable to be tested. Upon a light-flash signal from the experimenter, the subject grasped the handwheel, crank, or crossbar and turned it one revolution clockwise, watching the indicator dial. When the indicator hand came to rest exactly on the 0 mark, the control device was released. When the subject was satisfied that he had made an accurate setting, he depressed a toggle switch mounted to the left of the dial which indicated that the operation was at an end. This introduced the need for the subject to make a decision as to accuracy and to be satisfied with his decision before ending the operation.

Recording Equipment. Two records were kept of the subject's performance. A time record was kept by means of two synchronous electric clocks operating through two thyratron circuits closed by the subject. One of the two leads from the circuits was grounded to the control device and the second was attached to the subject's ankle. The potential across the leads was 6 volts. When a subject grasped the control device, both clocks started through the two thyratron circuits. The first clock ceased to operate immediately when the subject released the control device. The second clock was stopped by the toggle switch operated by the subject after the control device was released. The observer recorded the time from each clock and

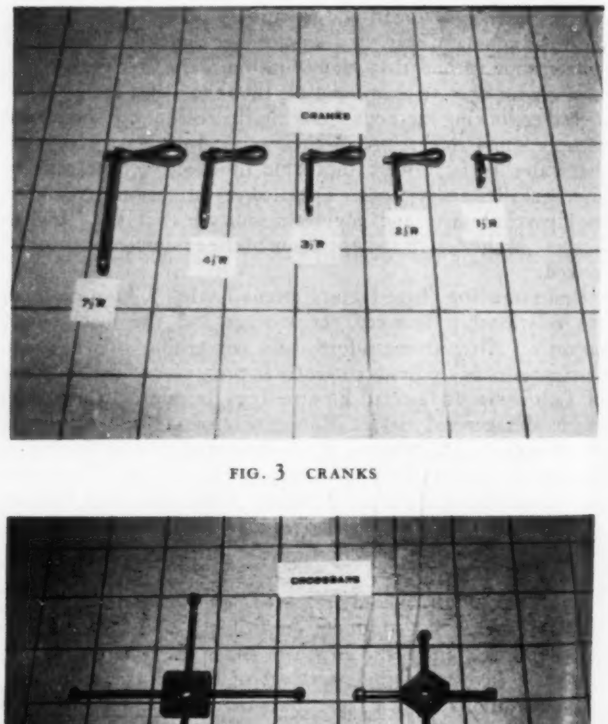

FIG. 3 CRANKS

FIG. 4 CROSSBARS

then turned on a signal light indicating that the next trial could commence.

A graphic record also was kept by a pen attached to the shaft turning the indicator hand. A second pen, mounted in a stationary position, marked dead-center point of the indicator hand. Both pens recorded on a kymograph which moved a paper tape at a constant rate of speed. The graphic record provided information on smoothness of movement, under or overshooting of the dead-center position, and on hunting or bracketing practices of the subject. This record was examined periodically to insure that the subject was not biased in his decisions as to the accuracy of his work. The operation was under the experimenter's observation as well.

RESULTS OF TESTS

The results are presented in graphic and tabular form. In all cases they are the mean of mean of the last five of the ten trials run with each variable for each subject. The original data were plotted for each location position, height, and size and type of control device. The variations of each trial for each subject about the grand mean plot for each set of conditions fell within 2σ limits, indicating that the data collected for each subject were in "control."

During the training period the subjects were instructed in the methods to use in performing the operation. Variations in location of the control devices and in the frictional torque on the control shaft necessitated changes in method of grasping and operating the devices. It was observed throughout the tests that the subjects used approximately the same methods in performing the operation. This eliminates the possibility of variations in data due to differences in methods of operation.

During all of the tests care was exercised to eliminate the influence of fatigue of the subjects on the results. Only 1 hr per day was spent in the laboratory, and this was divided into short work periods, followed by rest pauses. Short work sessions were employed to maintain a high level of motivation and to reduce the possibilities of the onset of fatigue.

Fig. 5 shows the results of the nine subjects operating hand-

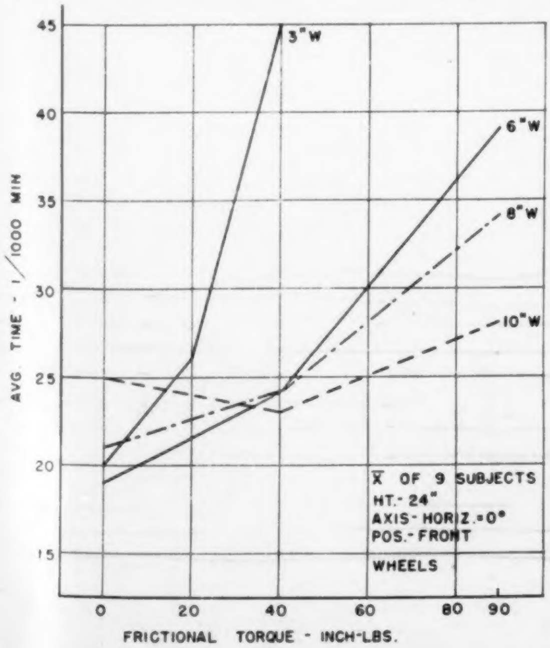

FIG. 5 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS AT 24 IN. HEIGHT, HORIZONTAL AXIS OF ROTATION

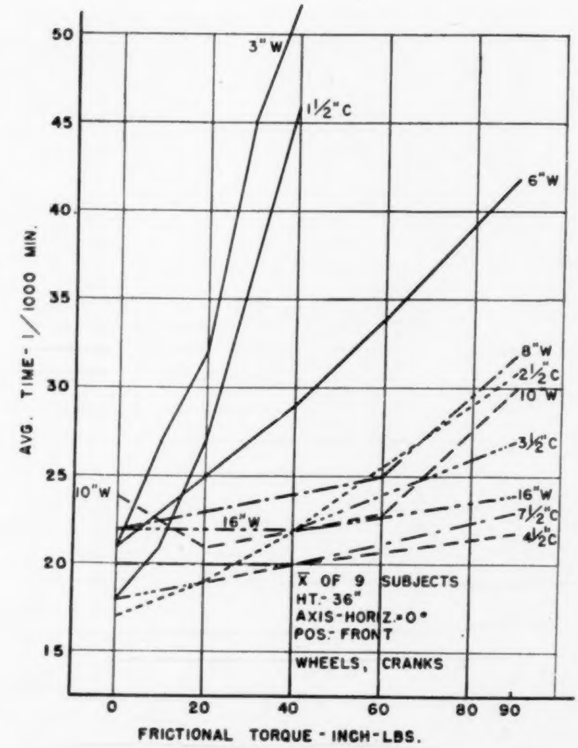

FIG. 6 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS AND CRANKS AT 36-IN. HEIGHT, HORIZONTAL AXIS OF ROTATION

wheels at the 24-in. distance from the floor. For all of the subjects this necessitated stooping over and operating the wheels at slightly above knee level. Excluding the smallest wheel size, 3 in. diam, the divergence point, at which there is no significant difference between the sizes is 40 in-lb of frictional torque. With torques smaller than this, the larger the wheel size the poorer the performance, while with torques larger than this, the larger the wheel size the better the performance. The larger the torque, the larger the difference becomes in favor of the larger wheel size. In general, the performance of all the sizes, except the 6-in-diam size, is comparable to that turned in at the 36-in. height for the same operating position.

Fig. 6 shows the results for all subjects operating handwheels and cranks at the 36-in. distance from the floor. This height may be said to be the one most representative of actual control-device location on standard machine tools. For comparable sizes and torques, the cranks give a better performance than the handwheels. While the differentials between sizes are smaller, there is no pronounced divergence point. However, a leveling-off takes place at the 60-in-lb torque for the handwheels and at the 40-in-lb torque for the cranks. The differences in performance between the various sizes is not as pronounced for the torques below the leveling-off points. In general, above 40 in-lb of torque, there appears to be a correlation between size and torque.

Fig. 7 shows the results for all of the subjects operating handwheels at the 36-in. distance from the floor with a horizontal axis of rotation, but standing at right angles to the axis of rotation. The divergence point, while not pronounced, is at the 10-in-lb torque. For torques above this point, the larger the wheel, the better the operating results, and the larger the differences in performance become in favor of the larger-sized wheels. In general, the performance in this operating position

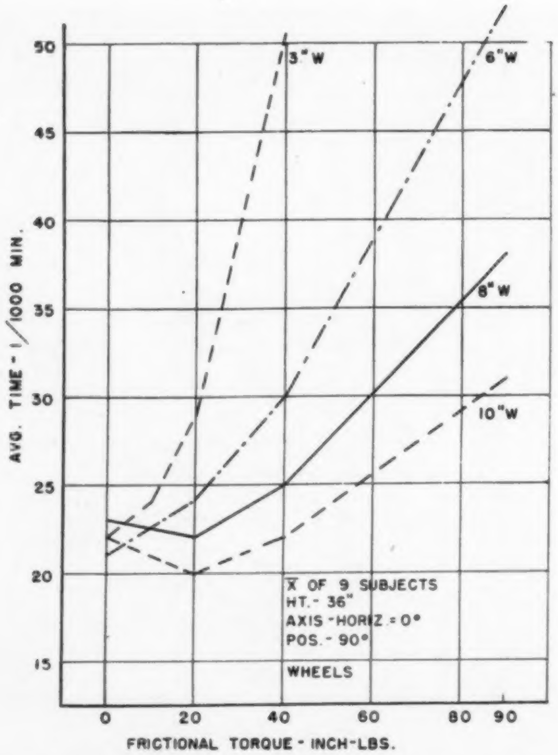

FIG. 7 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS AT 36 IN. HEIGHT, HORIZONTAL AXIS OF ROTATION, WITH SUBJECT STANDING AT 90 DEG TO AXIS

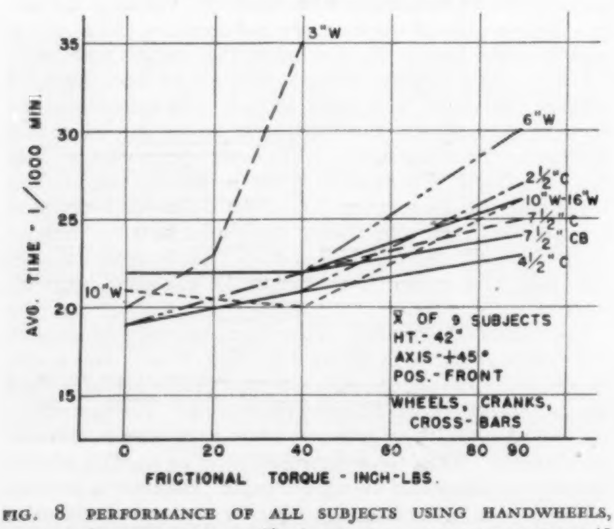

FIG. 8 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS, CRANKS, AND CROSSBARS AT 42 IN. HEIGHT; AXIS OF ROTATION 45 DEG ABOVE HORIZONTAL

is poorer than when the subjects stand facing the control devices.

Fig. 8 shows the results of all of the subjects operating handwheels, cranks, and crossbars at the 42-in. distance from the floor with an axis of rotation 45 deg above horizontal. The divergence point is at 40 in-lb of torque. At the largest torque, 90 in-lb, the cranks turn in a better performance than the handwheels. Again there is a positive correlation between size of control device and frictional torque above the divergence point for optimum performance. Below this point the correlation is negative between size of device and torque for optimum performance. There seems to be no essential difference in performance between cranks and crossbars. There is a closer dispersion in performance between the sizes than noted with the other conditions so far reported. Performance with cranks is slightly better than with wheels of comparable sizes at higher torques. In general, the performance in this operating position is better with the small wheels, 3 in. diam, 6 in. diam, but is the same with the other devices tested as compared to the 36-in. height.

Fig. 9 shows the results of all the subjects operating handwheels, cranks, and crossbars at the 40-in. distance above the floor with an axis of rotation 45 deg below horizontal. The divergence point is at 40 in-lb torque. A comparable perform-

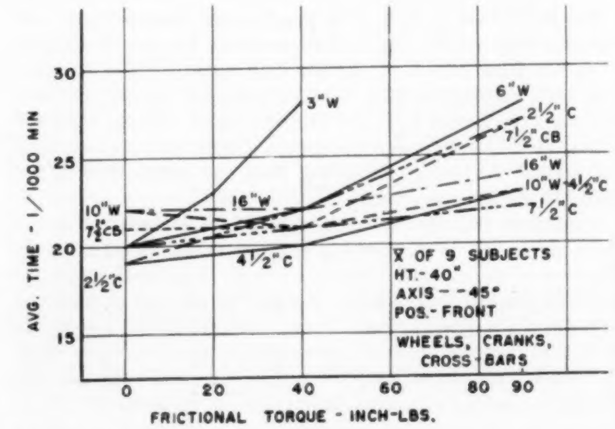

FIG. 9 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS, CRANKS, AND CROSSBARS AT 40 IN. HEIGHT; AXIS OF ROTATION 45 DEG BELOW HORIZONTAL

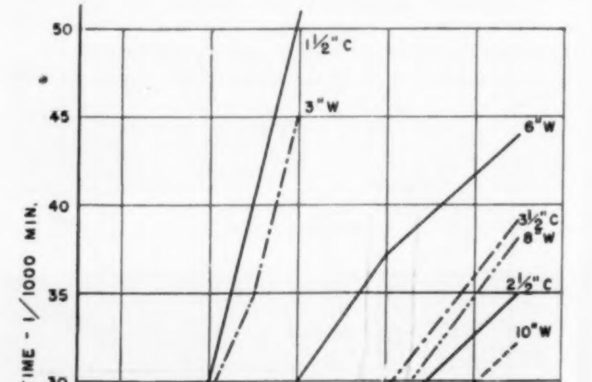

FIG. 10 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS AND CRANKS AT 39 IN. HEIGHT, VERTICAL AXIS OF ROTATION

TABLE 1 PERFORMANCE OF ALL SUBJECTS FOR ALL CONDITIONS, SHOWING AVERAGE TIME IN 1/1000 MIN

(Control devices are related to best performance for each torque in per cent.)

Operating Position	Height Above Floor	Type of Control	Torque in inch lbs.	Size of Control: 3"D Wheel or 1½"R Crank Time^A	%^B	6"D Wheel or 2½"R Crank Time	%	8"D Wheel or 3½"R Crank Time	%	10"D Wheel or 4½"R Crank Time	%	16"D Wheel or 7½"R Crank Time	%	2σ Limits About $\bar{X}$^C
0°	24"	Wheel	0	20	105	19	100	21	110	25	132	-	-	± .63
			20	26	137	19*	100	22*	116	24*	126	-	-	± .69
			40	45	196	24	104	24	104	23	100	-	-	± .73
			90	-	-	39	139	34	122	28	100	-	-	± .79
0°	36"	Wheel	0	21	100	21	100	22	105	24	114	22	105	± .58
			20	32	152	25	119	23	110	21	100	22*	105	± .61
			40	52	236	29	132	24	109	22	100	22	100	± .64
			60	-	-	34	148	25	109	23	100	23*	100	± .64
			90	-	-	42	175	32	133	30	125	24	100	± .65
⊥	36"	Wheel	0	22	105	21	100	23	110	22	105	-	-	± .70
			20	29	145	24	120	22	110	20	100	-	-	± .65
			40	51	232	30	136	25	114	22	100	-	-	± .74
			90	-	-	52	168	38	122	31	100	-	-	± 1.11
0°	36	Crank	0	18	103	17	100	18	103	18	103	20	118	± .49
			20	27	142	19	100	19	100	19*	100	20*	105	± .50
			40	46	230	22	105	22	105	20	100	20	100	± .53
			90	-	-	31	141	27	123	22	100	23	104	± .44
90°	39	Wheel	0	19	100	19	100	22	116	20	105	21	110	± .47
			20	29	152	21	110	21	110	19	100	21	110	± .55
			40	45	214	30	143	23	105	21	100	21	100	± .63
			60	-	-	37	161	28	117	25	109	23	100	± .57
			90	-	-	44	169	38	146	32	123	26	100	± .68
90°	39	Crank	0	21	110	19	100	19	100	20	105	22	116	± .52
			20	30	150	21*	105	21*	105	20*	100	22*	110	± .59
			40	51	243	23	110	23	110	21	100	22	105	± .58
			90	-	-	35	146	29	121	25	104	24	100	± .64
-45°	40	Wheel	0	20	100	20	100	-	-	22	110	22	110	± .54
			20	23	109	21*	114	-	-	22*	100	22*	100	± .43
			40	28	133	22	104	-	-	21	100	22	104	± .46
			90	-	-	28	122	-	-	23	100	24	104	± .48
-45°	40	Crank	0	-	-	19	100	-	-	19	100	20	105	± .56
			40	-	-	22	110	-	-	20	100	21	105	± .46
			90	-	-	27	123	-	-	23	104	22	100	± .52
-45°	40	Cross Bar	0	-	-	-	-	-	-	-	-	21		
			40	-	-	-	-	-	-	-	-	22		
			90	-	-	-	-	-	-	-	-	26		
+45°	42	Wheel	0	20	105	19	100	-		21	110	22	116	± .45
			20	23	110	21*	100	-	-	21*	100	22*	105	± .52
			40	35	175	22	110	-	-	20	100	22	110	± .49
			90	-	-	30	150	-	-	26	100	26	100	± .50
+45°	42	Crank	0	-	-	19	100	-	-	19	100	22	116	± .55
			40	-	-	21	100	-	-	21	100	22	105	± .46
			90	-	-	27	112	-	-	23	100	25	109	± .49
+45°	42	Cross Bar	0									22		
			40									22		
			90									24		
0°	48	Wheel	0	18	100	19	106	20	111	20	111	21	116	± .49
			20	23	115	21*	105	20*	100	20*	100	21*	105	± .52
			40	34	170	22	110	20	100	20	100	21	105	± .50
			90	-	-	34	142	29	121	24	100	25	104	± .52
0°	48	Crank	0	18	112	16	100	17	106	17	106	18	112	± .44
			20	26	144	19*	106	19*	106	18*	100	19*	106	± .50
			40	43	226	21	110	21	110	19	100	21	110	± .46
			90	-	-	35	159	27	123	23	105	22	100	± .63
0°	48	Cross Bar	0							19	100	21	110	± .40
			40							25	114	22	100	± .45
			90							26	113	23	100	± .52
0°	58	Wheel	10	21	117	18	100	-	-	21	117	23*	128	± .47
			20	25	131	19*	100	-	-	21*	110	23	121	± .45
			40	38	173	22	100	-	-	22	100	23	104	± .56
			90	-	-	32	123	-	-	26	100	28	108	± .54
0°	58	Crank	10	-	-	20	105	-	-	19	100	22	116	± .51
			40	-	-	22	100	-	-	22	100	24	109	± .48
			90	-	-	36	144	-	-	25	100	27	108	± .69
0°	58	Cross Bar	10	-		-		-		-		21		
			40	-		-		-		-		22		
			90	-		-		-		-		26		

ance is turned in by both handwheels and cranks size for size. Crossbar performance is poorer than both wheels and cranks for comparable sizes. There is a close dispersion in performance between the sizes of control devices. In general, the performance in this operating position is better with the handwheels but is the same for the other devices, as compared to the 36-in. height.

Fig. 10 shows the results of all of the subjects operating handwheels and cranks at the 39-in. distance from the floor with a vertical axis of rotation. The divergence points are at 40 in-lb torque for the cranks and at 20 in-lb torque for the wheels. Except for the 10-in-diam wheel, compared to the $4^1/_2$-in-radius crank, comparable performances are achieved with the same sizes of cranks and wheels. Comparable performances are given with the wheels in this location and with them in the 36-in. height, horizontal axis location, Fig. 6. A poorer performance is given with the cranks when comparing these two locations.

Fig. 11 shows the results of all of the subjects operating handwheels, cranks, and crossbars at the 48-in. distance from the floor. The divergence point is at 40 in-lb. Crossbars give a poorer performance than cranks of comparable size. The cranks turn in a better performance than the handwheels of comparable size. Cranks at the 36-in. height give a performance comparable to those at this height. With the exception of the 6-in-diam size, wheels at this height give a performance comparable to that given by them at the 36-in. height.

Fig. 12 shows the results of all of the subjects operating handwheels, cranks, and crossbars at the 58-in. distance from the floor. The divergence point is at 40 in-lb. Cranks and handwheels turn in a comparable performance. The 6-in-diam wheel gives a better performance, while the 16-in-diam wheel gives a poorer performance at this height than at the 36-in. height. The other wheels are comparable. All sizes of cranks turn in a poorer performance at this height than at the 36-in. height.

Table 1 gives the performance of all subjects for all conditions. The performance time is the mean of the mean of the last five trials for each condition for each subject, and is given in thousandths of a minute. For each height, location, type of control device, and torque, the performance of each size of device is related to the best in per cent. To make for ease in discriminating significant differences between sizes of devices for each set of conditions, the 2σ limits about each time value $(\bar{X})$ is furnished. With these limits given, a cursory test of significance, in

NOTES TO TABLE 1

(A) Time: Time in 1/1000 min. $\bar{X}$ of 9 subjects performing under each set of conditions

(B) Per cent: Best performance = 100 per cent.

(C) 2 σ Limits about $\bar{X}$: Any time value shown in table $(\bar{X})$ could likely vary due to chance causes between the limits shown 95 out of 100 times if the experiment were to be repeated.

* Interpolated.

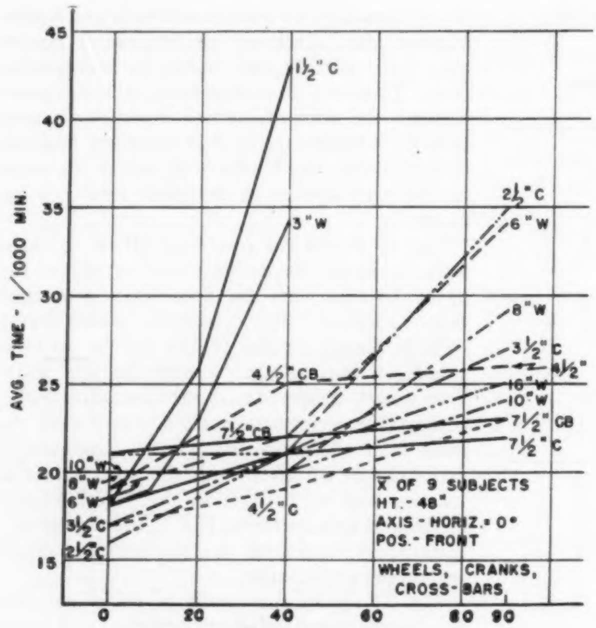

FIG. 11 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS, CRANKS, AND CROSSBARS, AT 48 IN. HEIGHT; HORIZONTAL AXIS OF ROTATION

place of the more formal *t*-test, can be made by adding the limits to the values and then comparing them.

Table 2 gives the optimum sizes of each control device for each set of conditions. The optimum size was determined by best performance in each case. This table is a condensation on the basis of performance of the data furnished in Table 1.

CONCLUSIONS

The conclusions are based upon results of laboratory experiments, involving male college students, where care was exercised to keep the influence of fatigue at a minimum. They apply to a machine control situation in which discrete single settings of an indicator to close tolerance limits are made that involve one or more revolutions of the control device.

1 For each control location there is a breaking point or a divergence point at which the relationship between size of device used and performance changes. This divergence point is usually at the 40 in-lb torque. Above this point, the larger the control device, the better the performance achieved; below this point, the smaller the size of control device, the better the results. Above the divergence point, the larger the frictional torque, the larger the difference grows in favor of the larger devices.

2 Performance at each control location varies as compared with the 36-in. height, horizontal axis, 0 deg position location, which is most commonly found on machine tools, as follows:

(*a*) Performances at the 24-in. height and at the 48-in. height are equal to those at the 36-in. height.

(*b*) At the 36-in. height, right-angle position, performance is poorer than at the 36-in. height.

(*c*) Except for the small sizes of wheels at which the 42-in. height, +45-deg axis is better; performance at this location is equal to that at 36-in. height.

(*d*) At the 40-in. height, —45-deg axis, performance with handwheels is better as compared to the 36-in. height, and performances with cranks are comparable for both locations.

(*e*) Performances with handwheels at the 39-in. height, vertical-axis location, and at the 58-in. height, horizontal-axis location, are comparable to those at the 36-in. height. However, poorer performances are given with the cranks at these locations than at the 36-in. height.

(*Continued on page 837*)

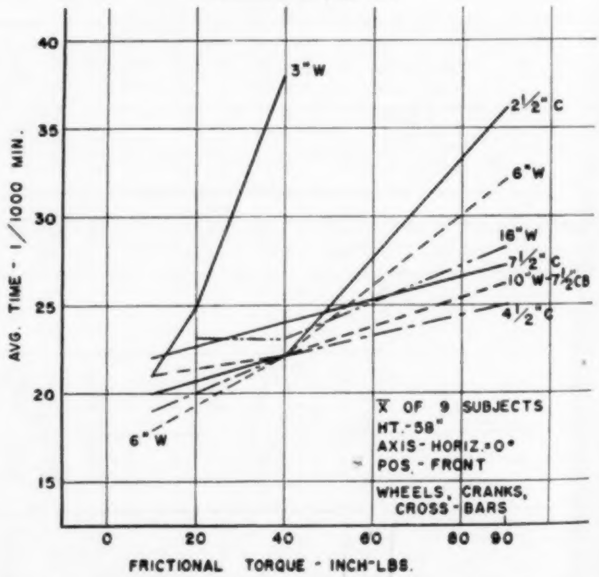

FIG. 12 PERFORMANCE OF ALL SUBJECTS USING HANDWHEELS, CRANKS, AND CROSSBARS AT 58 IN. HEIGHT, HORIZONTAL AXIS OF ROTATION

TABLE 2 OPTIMUM SIZE OF CONTROL DEVICE FOR EACH SET OF VARIABLES[a]

Height, in.	Position, deg	Type	Torque	Optimum sizes, in.	Torque	Optimum sizes, in.	Torque	Optimum sizes, in.	Torque	Optimum sizes, in.
24	0	W	0	3, 6	20	6*	40	10	90	16
36	0	W	0	3, 6, 8	20	10, 16*	40	10, 16	90	16
36	L	W	0	3, 6	20	10	40	10	90	10
36	0	C	0	$1\tfrac{1}{2}$, $2\tfrac{1}{2}$, $3\tfrac{1}{2}$, $4\tfrac{1}{2}$	20	$2\tfrac{1}{2}$, $3\tfrac{1}{2}$, $4\tfrac{1}{2}$, $7\tfrac{1}{2}$*	40	$4\tfrac{1}{2}$, $7\tfrac{1}{2}$	90	$4\tfrac{1}{2}$, $7\tfrac{1}{2}$
39	90	W	0	3, 6, 10	20	10	40	10, 16	90	16
39	90	C	0	$2\tfrac{1}{2}$, $3\tfrac{1}{2}$, $4\tfrac{1}{2}$	20	$2\tfrac{1}{2}$, $3\tfrac{1}{2}$, $4\tfrac{1}{2}$*	40	$4\tfrac{1}{2}$, $7\tfrac{1}{2}$	90	$4\tfrac{1}{2}$, $7\tfrac{1}{2}$
40	—45	W	0	3, 6	20	10, 16*	40	6, 10, 16	90	10, 16
40	—45	C	0	$2\tfrac{1}{2}$, $4\tfrac{1}{2}$, $7\tfrac{1}{2}$	20	$2\tfrac{1}{2}$, $4\tfrac{1}{2}$, $7\tfrac{1}{2}$	40	$4\tfrac{1}{2}$, $7\tfrac{1}{2}$	90	$4\tfrac{1}{2}$, $7\tfrac{1}{2}$
42	+45	W	0	3, 6	20	6, 10*	40	10	90	10, 16
42	+45	C	0	$2\tfrac{1}{2}$, $4\tfrac{1}{2}$	20	$2\tfrac{1}{2}$, $4\tfrac{1}{2}$	40	$2\tfrac{1}{2}$, $4\tfrac{1}{2}$	90	$4\tfrac{1}{2}$
48	0	W	0	3, 6	20	6, 8, 10, 16*	40	8, 10, 16	90	10, 16
48	0	C	0	$2\tfrac{1}{2}$, $3\tfrac{1}{2}$, $4\tfrac{1}{2}$	20	$2\tfrac{1}{2}$, $3\tfrac{1}{2}$, $4\tfrac{1}{2}$, $7\tfrac{1}{2}$*	40	$4\tfrac{1}{2}$	90	$4\tfrac{1}{2}$, $7\tfrac{1}{2}$
58	0	W	10	6	20	6*	40	6, 10, 16	90	10
58	0	C	10	$2\tfrac{1}{2}$, $4\tfrac{1}{2}$	20	....	40	$2\tfrac{1}{2}$, $4\tfrac{1}{2}$	90	$4\tfrac{1}{2}$

[a] Optimum size determined by best performance.
* Based on interpolated data.

The Theory of Ultrasonic

MATERIALS TESTING[1]

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THE objective of all materials testing is to obtain information about the physical state of a specimen. The techniques employed depend upon the required information; which may involve the electrical, magnetic, elastic, optical, thermal, or chemical properties of the part.

When the properties to be determined are mechanical, it is then logical to utilize mechanical phenomena. Since vibratory motion in elastic materials is included in this category, it is consistent that its most common manifestation, acoustical waves, should be considered for nondestructive materials testing.

Although ultrasonic principles have been understood for almost 100 years, it is noteworthy that only through modern electronic techniques have they been extensively applied.

While the terms supersonic and ultrasonic are sometimes used interchangeably, there are two distinct aspects of sound involved, (1) velocity and (2) frequency.

When speeds are lower than, equal to, or greater than sound velocity, they are commonly referred to as subsonic, transsonic, and supersonic. These terms thus apply only to the speed of motion and relate principally to the fluid dynamics. Fig. 1 suggests graphically that aspect of sound usually

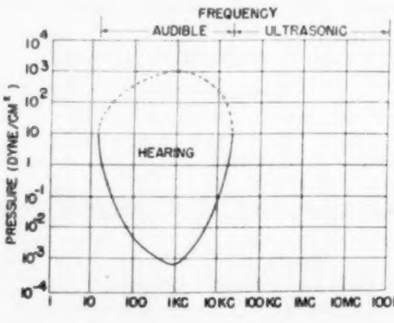

FIG. 1 THE ACOUSTIC SPECTRUM

associated with the term ultrasonic, that is, frequency. It infers that audible vibrations are but part of the spectrum of mechanical waves in elastic materials. Consider a closed organ pipe producing in air a sound pressure of 10 dynes per sq cm. When 12 ft long it produces an audible rumble of 20 cps, 4 octaves below middle C. When $^1/_8$ in. long, it generates a high-pitched whistle of 20,000 cps, 6 octaves above C, but still audible to most people. This represents a frequency range of 10 octaves for the audible spectrum.

Immediately above this upper frequency limit of audibility, acoustic vibrations can be generated by special sirens, pipes

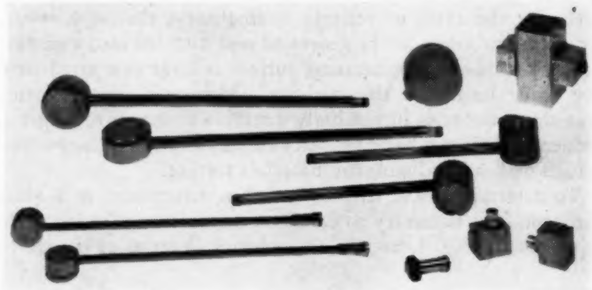

FIG. 2 A VARIETY OF TRANSDUCERS FOR ULTRASONIC TESTING

such as the familiar inaudible dog whistles, and a variety of electromechanical devices. They are produced in nature by bats and insects.

Electromechanical methods for producing high-frequency vibratory motion depend on two phenomena. These are mag-

GENERAL	$\xi = F_F(vT - x) + F_B(vT + x)$	(1)
DISPLACEMENT	$\xi = A \sin 2\pi f(T - \frac{x}{v})$	(2)
VELOCITY	$\frac{\partial \xi}{\partial T} = 2\pi f A \cos 2\pi f(T - \frac{x}{v})$	(3)
ACCELERATION	$\frac{\partial^2 \xi}{\partial T^2} = (2\pi f)^2 A \sin 2\pi f(T - \frac{x}{v})$	(4)

FIG. 3 EQUATIONS OF IDEALIZED ELASTIC WAVES

netostriction and piezoelectricity. Magnetostriction describes the property of materials to change dimensions when subjected to a magnetic field; thus the dimensions can be caused to vary rapidly by the application of an alternating magnetic field. Vibrations up to 200,000 cps can be produced. Piezoelectricity describes the ability of certain crystalline materials to vary in dimensions with an applied electric field. This and its inverse effect are the basis for crystal phonograph pickups, microphones, vibration analyzers, etc. By proper dimensioning, their operating range can be extended far beyond audibility in both frequency and pressure. A variety of quartz-crystal transducers for materials testing at one million cps is shown in Fig. 2.

Mechanical vibrations traveling through materials can be described mathematically in terms of the following properties which are not necessarily independent: (1) Amplitude, (2) velocity of propagation, (3) frequency, (4) mode of particle movement, (5) boundary conditions, and (6) loss factor.

Fig. 3 specifies the idealized elastic wave applicable to materials inspection, that is, a plane wave having constant velocity V and negligible losses. Sound losses are low in homogeneous solids and in liquids but are very high in gases.

A displacement initiated within a perfectly elastic medium is propagated without loss as a forward-wave amplitude F_f and a

[1] One of three papers presented on ultrasonic testing. The remaining two cover instrumentation and practice and appear in condensed form on pp. 846–847, of this issue of MECHANICAL ENGINEERING.

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Contributed by the Railroad Division and presented at the Annual Meeting, New York, N. Y., November 28–December 3, 1948, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

backward-wave amplitude F_B, described in Equation 1. A single unrepeated impulse is called a shock wave. If the particle displacement ξ is caused to vary with a sinusoidal motion, Equation 2 applies. In such a case it follows from Equations [3] and [4] that the particle velocity increases directly with the frequency f, and the particle acceleration as the frequency squared. Thus an ultrasonic wave having the same amplitude displacement as a low-frequency sound, should exert considerably more particle disruptive force. Interesting effects of a high-intensity beam are the emulsification of immiscible liquids and the destruction of bacteria.

Equation 2 permits the use of the convenient concept of wave length, since for simple harmonic waves, the wave length is given by the ratio of velocity to frequency, that is, $\lambda = {}^{v}/_{f}$. Now a plane wave can be generated and directed into a narrow beam, provided the generating surface is large compared with the wave length in the medium. Moreover, the radiating transducer becomes increasingly directive as the wave length is reduced. This is a basic property of very high-frequency sound which makes it valuable for materials testing.

To determine wave length, and thus directivity, in a given medium, it is necessary to calculate or measure velocity. The equations of Fig. 4 describe the velocity in terms of the elastic

GENERAL $\quad v = \sqrt{\dfrac{\text{ELASTICITY}}{\text{DENSITY}}}$

LONGITUDINAL

A) THIN ROD $\quad v_B = \sqrt{\dfrac{E}{\rho}}$

B) BULK $\quad v_L = \sqrt{\dfrac{E}{\rho}\dfrac{(1-\sigma)}{(1+\sigma)(1-2\sigma)}} = \sqrt{\dfrac{K + \frac{4}{3}E_s}{\rho}}$

TRANSVERSE $\quad v_T = \sqrt{\dfrac{E}{\rho}\dfrac{1}{2(1+\sigma)}} = \sqrt{\dfrac{E_s}{\rho}}$

FIG. 4 EQUATIONS FOR SOUND VELOCITY IN SOLIDS

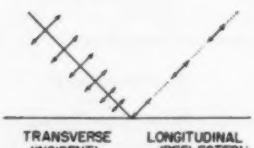

FIG. 5 THE CONVERSION OF A TRANSVERSE WAVE TO A LONGITUDINAL WAVE BY OBLIQUE REFLECTION

properties of the material. These state that mechanical waves propagate through materials with a velocity given by the square root of elasticity divided by density. The particular elastic constants involved depend upon the mode of vibration established by the generator. In liquids and gases having no shear elasticity, only a compressional wave can exist, and its velocity is determined by the dynamic bulk modulus and the density. In solids, however, two principal internal modes of vibration are predicted, longitudinal waves, having the particle vibration in the direction of propagation, and transverse waves, having the particle vibration perpendicular to the wave motion. Fig. 5 suggests the relative motion of these two types of waves, and how one might be converted to the other by reflection at a rigid interface. From the mode of vibration and the boundary conditions, three principal velocities can be defined for isotropic solids. These are as follows:

1 The Thin Rod longitudinal velocity V_B, given by Young's modulus E, and density ρ.

This is the so-called "stretch" velocity for wires or rods whose cross section is small compared with wave length. It is the value commonly given in handbooks for the sound velocity in solids, although it is usually not specified as such.

2 The Bulk longitudinal velocity V_L, given by the thin rod velocity and an additional factor determined by Poisson's ratio σ.

This is predicted velocity of sound through specimens whose cross section is large compared with wave length, the condition usually encountered in ultrasonic testing. Since $^1/_2 > \sigma > 0$, V_L is always greater than V_B. A second equation for V_L in terms of the bulk modulus K and the shear modulus E_S, is given to show the interdependence of the elastic constants.

3 The Transverse or Shear velocity V_T, given by the thin rod velocity and a second function of Poisson's ratio.

Because of the foregoing conditions on Poisson's ratio, the transverse velocity must lie between 0.577 V_B and 0.707 V_B. The transverse velocity can also be given in terms of the shear modulus. This indicates that transverse waves travel at the same rate as torsional waves generated by twisting a specimen.

The equations of Fig. 4 suggest at once an important application of ultrasonics to the study of materials—the determination of elastic constants by nondestructive tests on the actual specimen. Fortunately, by the proper selection of transducers and associated equipment, it is possible to isolate and measure both the bulk velocity and the shear velocity. Since the density is usually known or easily determined, all elastic constants can then be computed. Direct measurement of Poisson's ratio and bulk modulus by other methods are ordinarily difficult even on specially shaped test samples. The values of the elastic constants for steel and the computed sound velocities are given in Table 1. The velocities for other common materials, as well as the wave length associated with frequencies used for ultrasonic testing are shown in Table 2.

From these wave lengths it is evident that ordinary objects requiring internal inspection meet the condition that the cross section is large compared with the wave length of the ultrasonic beams used. Moreover, compact transducers can be used

TABLE 1 PROPERTIES OF STEEL

Specific gravity	Density	Elastic constants E	E_S	σ	Sound velocities V_B	V_L	V_T
7.83	0.283 p.c.i.	30 $\times 10^6$ psi	12	0.25	2.03	2.23 $\times 10^5$ in./sec.	1.29

TABLE 2 WAVE LENGTHS AT ULTRASONIC FREQUENCIES

Material	Velocity $V_L \times 10^5$ in./sec.	Wave length in. 1.0	5.0	10 megacycle
Steel	2.23	0.223	0.0446	0.0223
Brass	1.29	0.129	0.0258	0.0129
Al alloy	2.34	0.234	0.0468	0.0234
Mercury	0.56	0.056	0.0112	0.0056
Water	0.59	0.059	0.0118	0.0059
Air	0.13	0.013	0.0026	0.0013

as sound generators having a cross section of less than one square inch, yet still be several wave lengths in linear dimensions at frequencies above 1.0 megacycle. A 1-in-diam quartz crystal, vibrating at 1.0 megacycle against a steel block, will generate in the block a beam whose energy is confined principally to a cone of 30 deg. At 5.0 mc the beam divergence is reduced to 6 deg. These results are obtained from the formula $\phi = 2\sin^{-1}(1.22\lambda/D)$, where ϕ is the apex angle of a cone containing the primary beam, λ is the wave length, and D the diameter of the radiation source.

The final property of ultrasonic waves of particular importance in materials testing, concerns wave reflection at physical discontinuities. An elastic displacement as described in the equations of Fig. 2 will travel through many feet of common materials before being dissipated by internal friction. How-

ever, if the ultrasonic beam encounters an abrupt change in the medium, a backward-traveling displacement is started as shown in Fig. 6. The ratio of reflected displacement ξ_R to incident displacement ξ_i is determined by the acoustic impedances of the two materials, R_1 and R_2, as given in the equation in Fig. 6. The acoustic impedance, R, is defined as the product of velocity and density. The transmitted displacement, ξ_T, is the difference between incident and reflected waves, and the intensity or energy of the respective waves is proportional to the square of the displacements. Values of the reflected energy W_R for a few commonly encountered interfaces are given in Table 3.

TABLE 3 RATIO OF REFLECTED TO INCIDENT ENERGY

Medium 1	Medium 2	R_1	R_2	ξ_R/ξ_i	W_r/W_i
Water	Steel	$.0214 \times 10^5$	0.63×10^5	0.93	0.86
Mercury	Steel	0.273×10^5	0.63×10^5	0.40	0.16
Air	Water	565	0.0214×10^5	~ 1	~ 1
Air	Steel	565	0.63×10^5	~ 1	~ 1

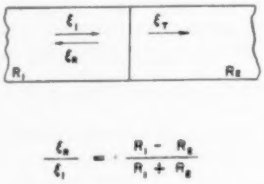

FIG. 6 REFLECTION OF ELASTIC WAVE AT PHYSICAL DISCONTINUITY IN MEDIUM

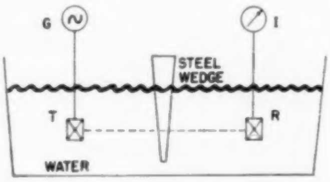

FIG. 7 EXPERIMENTAL METHOD FOR MEASURING TRANSMISSION THROUGH SOLID IMMERSED IN LIQUID

It should be noted that these pertain to a single discontinuity between two essentially infinite media. A more complicated case results when a thin layer of material is bounded on each side by a second material, such as a steel plate immersed in water. An actual experimental setup for investigating this condition is diagramed in Fig. 7. The predicted energy reflected by a plate of thickness l at normal incidence is given by

$$W_R = \left(\frac{\xi_R}{\xi_i}\right)^2 = \frac{\left(\frac{R_1}{R_2} - \frac{R_2}{R_1}\right)^2}{4\cot^2 \frac{2\pi l_2}{\lambda_2} + \left(\frac{R_1}{R_2} + \frac{R_2}{R_1}\right)^2}$$

Transmission is plotted in Fig. 8 for one ratio of acoustic impedance. Particularly interesting cases are the infinitely thin section or film, and the half-wave plate, both exhibiting high transmission, and the quarter-wave plate showing high reflectivity. These conditions of resonance result from superposition of the forward and backward traveling waves given in Fig. 2, exactly analogous to so-called standing waves on electrical transmission lines. In low-loss materials harmonic

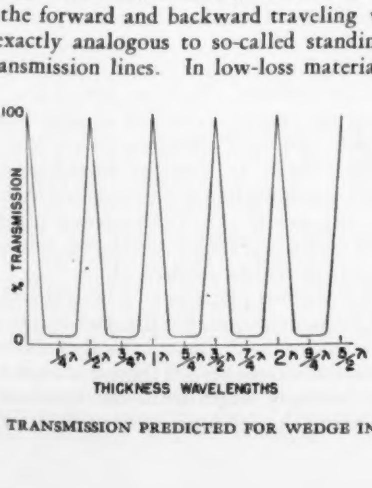

FIG. 8 TRANSMISSION PREDICTED FOR WEDGE IN FIG. 7

effects can be observed for thick sections which are integral multiples of one half-wave length in thickness. The principles can be extended to cover oblique incidence and multiple interfaces.

The foregoing properties of ultrasonic waves suggest a variety of techniques applicable to materials testing. The three basic testing methods most commonly used are diagramed in Fig. 9, and depend in order upon these phenomena: (1) transmission, (2) resonance, and (3) reflection. The high-frequency electric generator is shown as G, the ultrasonic

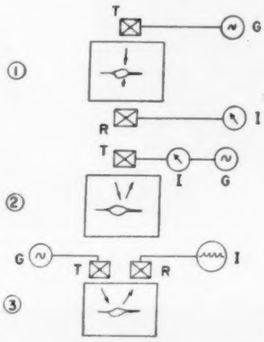

FIG. 9 THREE BASIC TECHNIQUES OF ULTRASONIC INSPECTION

transmitter as T, the ultrasonic receiver as R, and the indicating equipment as I. In each case a liquid film, such as machine oil, is used between the transducers and sample to conduct the sound, since an air gap introduces excessive losses.

In method (1) an ultrasonic beam is transmitted through the sample to be inspected and the received energy is indicated. Internal defects result in a decrease in transmission as predicted in the discussion on interfaces.

In method (2) a single transducer is used to indicate standing waves within the sample which react on the generator. Refinements of this technique permit the measurement of velocity, thickness, and internal losses, with the advantage that contact is required with but one face on the sample.

In method (3) that portion of the ultrasonic beam is indicated which is reflected back toward the transmitter. This may be detected either by the transmitter crystal or by a separate receiver as shown in the sketch. Again, access to only one surface is necessary. The indicating device is usually a cathode-ray oscilloscope from which considerable information can be obtained about the internal condition of even the largest specimens. The method is adaptable to the measurement of thickness and sound velocity as well as to flaw detection.

A transmission test is illustrated in Fig. 10 and a reflection test in Fig. 11. These show actual industrial instruments.

Finally, from a review of these basic characteristics of ultrasonic waves which have been outlined, potentialities as well as limitations of their application to materials testing can be deduced. A summary of useful and limiting characteristics follows:

1 *Mechanical Phenomenon.* Ultrasonics, following the laws of mechanical acoustics are well suited to physical testing, including the study of elastic properties, the measurement of thickness, and the detection of flaws.

Nonmechanical properties such as color, permeability, chemical composition, etc. can be studied only to the extent that they affect the elastic behavior of materials.

2 *Nondestructive.* Since only low-amplitude signals are required, the sample is not affected. Components to be used or those actually installed can therefore be inspected.

Such tests can, however, be correlated with breakage tests only on a statistical basis.

FIG. 10 TESTING BY ULTRASONIC TRANSMISSION

FIG. 11 TESTING A TURBINE BOLT BY THE REFLECTION METHOD

3 *Very Directive.* A narrow beam of ultrasonic energy can be generated and sent into a specimen with very small transducers. This permits accurate measurements of thickness and the location as well as detection of faults.

Defects must be of a size and orientation that will intercept the beam in order to be detected. Sections having small cross section or extreme curvature may be difficult to test.

4 *Penetrates Deeply.* In nonporous elastic materials such as steel, aluminum, glass, porcelain, and plastics, the ultrasonic beam travels several feet before its energy is greatly dissipated, thus exceeding the range of other testing methods, including x ray.

In less elastic materials such as lead, and in porous materials like cast iron, losses may be excessive.

5 *Instantaneous.* Ultrasonic testing equipment because of its electromechanical construction responds very rapidly. Indications are obtained as soon as the transducers are applied to the specimen, without the necessity of photography, ultraviolet light, premagnetization, or radiation protection.

6 *Versatile.* Provided the ultrasonic beam can be coupled into the sample by a suitable acoustic medium such as oil, the techniques described can be applied to a wide variety of contours, dimensions, surfaces, and materials. Applications described in the references range from thickness measurements on 0.025-in. sheet steel to flaw detection in 50-ton turbine rotors.

BIBLIOGRAPHY

1 "Flaw Detecting and Measuring Device," by F. A. Firestone, U. S. Patent 2280226, 1942.

2 "Ultrasonics," by D. Cochran and R. W. Samsel, *G. E. Review*, vol. 47, August, 1944, p. 39.

3 "Supersonic Measurement of Metal Thickness; Sonigage," by W. S. Erwin, *Iron Age*, vol. 154, Nov. 9, 1944, p. 59.

4 "Ultrasonics (Der Ultraschall,)" by Ludwig Bergmann, translated by H. S. Hatfield, John Wiley & Sons, Inc., New York, N. Y., 1942.

5 "Ultrasonic Lenses and Transmission Plates," by P. J. Ernst, *Journal of Scientific Instruments*, vol. 22, December, 1945, p. 238.

6 "Supersonic Reflectoscope for Interior Inspection," by F. A. Firestone, *Metal Progress*, vol. 48, September, 1945, p. 505.

7 "Standing Wave Technique of Thickness Measurements," by J. B. Butler and J. B. Vernon, *Journal of the Acoustical Society of America*, vol. 18, July, 1946, p. 212.

8 "A Text Book of Sound," by A. B. Wood, Bell, London, England, 1946.

9 "Detection of Cracks in Steel by Means of Ultrasonic Waves," by C. H. Desch, D. O. Sproule, and W. J. Dawson, *Welding Journal*, vol. 26, January, 1947, p. 1s.

10 "Wavelengths of Sound," by B. W. Henvis, *Electronics*, vol. 20, March, 1947, p. 134.

11 "Supersonic Measuring Means," by W. S. Erwin, U. S. Patent 2431233, 1947.

12 "Tricks With the Supersonic Reflectoscope," by F. A. Firestone, *Non-Destructive Testing*, vol. VII, Fall, 1948.

13 "Ultrasonics," by Benson Carlin, McGraw-Hill Book Company, Inc., New York, N. Y., 1949.

Some Instrumentation Requirements in an Atomic Power Plant

(*Continued from page 810*)

locations which are inaccessible because of radiation. Conventional glass mirrors and lenses are blackened in time by exposure to radiation, and plastic lenses cannot withstand the high temperatures, so optical systems must employ polished metal reflecting surfaces where exposed to radiation and heat in and around the reactor.

CONCLUSION

As may be inferred from this meager and incomplete discussion, much remains to be done in the development of instruments for operating and maintaining atomic power plants of the type described here.

Perhaps the biggest obstacle to development is the lack of instrument-testing facilities. There are only a few places in the country where the effect of radiation on materials and devices may be studied. Similarly, there are only a few places where liquid-metal systems are available for instrument testing. Nowhere is there a combination of radiation and high-temperature liquid metal such as will exist in this power plant. More and better testing facilities are being developed, however, so work on instrumentation will be accelerated.

Operation of the first plant may be limited somewhat by inadequacy of instrumentation, but this first operating experience will direct attention to the most critical problems and probably will reveal limitations beyond those discussed here. There is opportunity for many worth-while contributions from instrument specialists to the development of useful atomic power.

Design Features of the
TRANS-ARABIAN PIPE LINE

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THE main problem of construction which distinguishes the Trans-Arabian Pipe Line from a similar project in the United States is, of course, the remote location and the large supporting organization that had to be organized to back up the actual construction staff. A few of the engineering problems, however, are also somewhat unusual.

The Trans-Arabian line was first considered as a probable future venture several years before the war. Serious thought to its immediate construction, however, started in the latter part of 1943 when the U. S. Government considered the construction of such a line as a war measure. Little was known about the character of the country at that time, and it was not known whether it would be more desirable to terminate in Palestine, perhaps at Haifa where one branch of the Iraq petroleum line terminates, or to adopt the somewhat longer route into Egypt. At that time the largest pipe available in the United States with suitable properties for pipe-line construction was 26 in. in outside diameter. This pipe was fabricated by an electric welding process from steel plate which, at that time, was scarce. It seemed quite probable that if a line were built it would have to be built of 24-in. seamless pipe, just as the Big Inch Pipe Line had been. This was the largest suitable seamless pipe available at that time. Tentatively, a working stress of 65 per cent of the minimum yield point based on the nominal thickness without corrosion allowance was deemed proper, especially since the Big Inch line had performed satisfactorily when operating under these stress conditions. The possible variations in the thickness from nominal were ignored, simply being included in the factor of safety, as were allowances for corrosion. Experience had amply demonstrated that, except in special circumstances, corrosion allowances have little if any place in the design of a pipe line for crude oil. Normal crudes do not corrode the pipe, and such failures as may take place from soil corrosion outside are normally perforations which result in leaks but seldom if ever in breaks, since they have little effect on the over-all strength of the pipe. In this case, it was hoped to avoid any serious external corrosion by good wrapping and cathodic protection where the line is buried.

A capacity of 300,000 bpd was tentatively decided on, largely because this is close to the maximum quantity that can be put through 24-in. pipe without excessive pumping costs, and partly, perhaps, because it seemed that production of about this magnitude might be expected in the eastern part of Arabia by the time the pipe line could be constructed. The proposal of our Government to build a pipe line was seriously considered in 1943 and 1944 but was finally given up, no doubt largely because by the middle of 1944 the war had progressed to a point where it was fairly evident that it would be all over, in so far as Europe was concerned, before a pipe-line project could be completed. However, The Texas Company and the Standard Oil Company

FIG. 1 PROPOSED ROUTE OF THE TRANS-ARABIAN PIPE LINE

of California, who at that time were equal partners in the Arabian concession (present ownership: 30 per cent California Standard, 30 per cent The Texas Co., 30 per cent New Jersey Standard, 10 per cent Socony), authorized some preliminary engineering investigation, and after a reconnaissance at the end of 1944, their engineers recommended a route which, to all intents and purposes, is that indicated in Fig. 1 and is the route that is now being followed in the construction of the line.

When the war was over the same considerations that had prompted the Government to consider the construction of a pipe line continued to urge its construction by private industry. The length of the line from Eastern Arabia to the Mediterranean is between 1030 and 1070 miles, depending on the route selected (the surveyed distance on the present route is 1067.5 statute miles), whereas the tanker haul around the Arabian Peninsula and through the Suez Canal to Port Said is 3167 nautical miles or 3650 statute miles. It was estimated that about 62 tankers of the T-2 type would be required to handle 300,000 bpd around the Arabian Peninsula. Between 60 and 80 tankers of this type or larger would be needed to handle the capacity of the pipe line now projected. These tankers were not available and to construct them would unquestionably have required more steel than the pipe line, although the two figures for steel tonnage do have the same general order of magnitude. Also, pipe-line steel requires less fabrication than the same tonnage in ships. It was believed that the total cost of pipe-line transpor-

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tation would be substantially less than the expense of taking the oil around to Port Said by tanker.

When the design of the pipe line was re-examined in 1945, it became clear that the 24-in. pipe was too small for best economy, and that for a nominal average rate of 300,000 bpd (with some allowance for lost time) a thin-wall pipe of approximately 30 in. in diam would be preferable, and it was hoped that it might be possible to secure such pipe after the war. Actually, the procurement of pipe turned out to be difficult. The reason for mentioning this is that it affected the design of the line. The designers had to be guided by what could be had, as well as by what might be wanted. However, the pipe that is being used seems to be satisfactory, and is believed to represent a good solution to the problem. The pipe is being manufactured at Maywood, Calif., from plate rolled at Geneva, Utah. Half of the pipe is 30 in. in diam and half 31 in. in diam, and most of it has a nominal wall thickness of $^1/_4$ in. The steel is a medium carbon, medium-high-manganese material and is semikilled. Specification limits are as follows: 0.30 per cent max C, 0.85 per cent to 1.25 per cent Mn, 0.045 per cent max P, and 0.05 per cent max S. In general, most of the pipe actually runs about 0.25 to 0.26 carbon and about 1.0 manganese.

The reason for making half the pipe 30 in. and half 31 in. was to permit it to be telescoped to save shipping charges.

When the plate arrives at Maywood it is planed to exact size, rolled, and welded inside and out by the "Union-Melt" process. As fabricated, the pipe is about $^1/_2$ in. undersize in diameter. After fabrication it is put into a heavy steel die and expanded under hydraulic pressure to its full size. This expansion of course stretches the steel beyond the yield point, and the cold work makes a significant increase in the tensile strength, especially in the circumferential direction. The specifications call for the pipe after expansion to have a minimum circumferential yield strength of 52,000 psi and an ultimate of 65,000. Both of these figures are consistently exceeded and most of the material shows a yield strength over 60,000 psi. The expansion apparently causes a gain in yield strength of between 12,000 and 20,000 psi in the circumferential direction, and perhaps half as much in the axial direction. The cold work also increases the ultimate strength of the metal in the circumferential direction by as much as 3000 to 7000 psi; this effect may not be generally known.

After being expanded, the pipe is tested hydrostatically to 90 per cent of the minimum specified yield strength of 52,000 lb. Few failures result on this final test, but it is still interesting to note that some failures do occur. Even after the pipe has been stretched beyond the yield point during manufacture, pieces still occasionally fail at only 90 per cent of this pressure, or, in fact, somewhat less. A few failures also have been experienced in the field.

With pipe fabricated as outlined, the design basis for the pipe line was taken at 65 per cent of the nominal yield point based on nominal thickness, stresses being computed by the conventional outside-diameter or Barlow formula. Such a procedure gives an allowable working pressure of approximately 570 psi for 30-in. pipe having a nominal $^1/_4$-in. wall thickness. When the pipe line was laid out on the basis of a minimum flow of 315,000 bbl per operating day (300,000 bbl per average day) and $^1/_4$-in. wall thickness, it was found that at least eight pumping stations would be required, but by increasing the wall thickness of the pipe at the high-pressure part of the line to a maximum of $^7/_{16}$ in. the working pressure could be increased to 885 psi, and by this move it was possible to reduce the number of stations to six. When it is realized that each pumping station is not just a small building with some pumps deriving power from a utility line, as they were on the Big Inch project, but instead a new community out in the desert which has to be supplied with everything from the outside, this advantage can be seen in its true proportions. A community of this kind not only has to be self-sufficient in so far as Americans and a much larger number of Arab employees are concerned, but whether or not one plans it that way, will inevitably attract a large number of hangers-on from the Bedouins in the vicinity who will, if nothing more, at least expect to use the water that the company develops to take care of their flocks. The total number of persons to be supported directly or indirectly by the station facilities is surprisingly large to one accustomed to similar operations here at home. Moreover, to secure and retain a competent American operating staff in a location hundreds of miles from the nearest settlement of any size, the pipe-line company must provide recreational and other facilities far beyond those needed here or in Europe.

At the present time plans call for construction of six dwelling houses in addition to the superintendent's house, and a four-room bunkhouse for single employees. There will be a children's playground, a tennis court, a baseball diamond, and a swimming pool, besides a community center and an infirmary.

In addition to the housing for Americans there will be quarters for about 24 Arab families and 200 Arab bachelors. Thus it may be seen that the cost of constructing and operating a pipe-line station in the middle of the desert is something wholly beyond and apart from any mere pumping cost in terms of kilowatthours such as one might talk about here in the United States.

The northern plains of Arabia slope gently upward from east to west at a fairly uniform rate, reaching a summit in Trans-Jordan only a little more than a hundred miles from the Mediterranean coast. The maximum elevation on the pipe line is nearly 2900 ft at Milepost 785, but the controlling elevation for the line originally laid out was only about 2200 ft and was at about MP 1025.

At approximately MP 1032 the right of way plunges precipitously into a valley some 13 miles north of Lake Hula, descending to an elevation of 740 ft at MP 1042. This valley is the northern extension of the Jordan River drainage. Lake Hula drains into the Sea of Galilee about 12 miles to its south. The pipe line crosses the north end of the valley proper, although the river, still called the Jordan, or Nahr el Hasbani, extends some miles to the north in a narrow and broken canyon.

From here the route crosses a spur of hills, reaching an elevation of 1600 ft five miles from the valley floor, and again descends to the Nahr el Litani at MP 1052, elevation 700 ft. (Nahr= small river.) This river drains the Beqaa Valley in Lebanon, but turns sharply westward and empties into the Mediterranean $8^1/_2$ miles south of Sidon instead of entering the Jordan.

The pipe line again climbs to an elevation of 1700 ft across the southernmost spur of the Lebanese mountains, descending over 1000 ft to the terminal in the last four miles.

Although the pipe line was, as indicated, designed for six pumping stations, it began to appear (well after construction had actually started) that a larger capacity than 300,000 bpd might be badly wanted, and further, that obtaining more steel pipe for looping the original line would probably be all but impossible during the next two years if the steel shortage continued. Only a few months ago, therefore, the heavy and light pipe was reallocated so as to permit the addition of intermediate pumping stations which would make the total number of pumping stations ultimately twelve. This results in some unbalance when the line is operated with six stations, and also results in cutting the pressure of several of the first six stations below the original design limit. As it stands now, the line will have a total capacity of 315,000 bbl per actual operating day with six stations and slightly over 500,000 bbl if the intermediate stations are added.

The picture many people have of Arabia is a wilderness of sand, with perhaps a little water hole or well here and there supporting a few date palms. In a way this conception is not too bad for a part of the country. In fact, just to the north of Abqaiq where the major oil production of Arabian American Oil Company is now located, and covering a part of the field, there are sand dunes close to 100 ft high which move southward at rates approximating 50 ft a year over a base of chert. These dunes are indeed a serious obstacle to construction, but they are almost entirely confined to the first 40 miles of the line between Abqaiq and Qatif. As a matter of fact, the moving dunes probably cover less than a third of even this section. The line here was the first to be completed, and has been in successful operation for some time, handling oil to Qatif Junction whence it is delivered to the coast for loading ships pending the completion of the entire line.

The appearance and behavior of the sand dunes themselves are most interesting. The principal wind blows from one direction, a few degrees east of north, and this is obviously the cause of the dune formation. The mechanics of their progress is evident by examination, although the forces that start them to form may be less so. They have a gradual slope on the windward side and plunge into a steep slope at the angle of repose of the sand on the leeward side, and the steep slope in plan has the form of a new moon. The sand carried by the wind goes up the windward slope not more than a few feet above the surface and drops at the top of the leeward slope when its velocity is checked by the tremendous eddy that exists on the lee side. The sand then drops on the steep slope, and since the latter is already at the angle of repose it slides down. In this sense the dunes do not blow forward; they slide forward. They are apparently in a delicate state of equilibrium and are quite sensitive to changes in conditions. Their progress can be altered, and they can even be forced to destroy themselves by a relatively small amount of work intelligently applied.

The main point, however, is that the greatest proportion of the right of way is either not sandy at all, or is covered with a stable sand or sandy soil which supports a growth of small bushes and does not tend to shift. This latter type of terrain, largely confined to the first 150 miles of the line, has been found excellent for pipe-line construction and road building.

Farther to the west the terrain for many miles consists of flat rock and gravel plains, virtually treeless except for a few spots, but supporting an intermittent and sparse growth of grass on which the Bedouins graze their flocks of sheep, goats, and camels during favorable parts of the year. Some of the gravel plains are underlain with a material apparently containing a considerable proportion of gypsum. This appears quite hard on first examination, but it can be handled with a ditching machine. The worst part of the gravel plains, however, is that the truck tires quickly get through the thin layer of gravel and reduce the underlying material to an almost impalpable powder, which makes hauling difficult. A great deal of the rock plain is underlain with limestone at a depth which may vary from almost nothing to several feet below the surface. All of this limestone is fairly hard, and some of it is extremely hard.

Certain portions of the plain country are extremely rough, the surface being covered with fractured stone piled up in irregular heaps, making it impossible for road or other construction, even though it looks quite smooth from an airplane at an elevation of 1000 ft. Fortunately, however, it has been possible to avoid nearly all of the worst of this country by adjusting the route slightly.

All of this plain country is traversed by dry washes known as "wadies", which, in general, slope toward the north. The word "flow" is intentionally omitted, since most of them are dead wadies that never reach the Euphrates Riv. and have not actually discharged any water there for probably many thousands of years. However, water does run in them at times for some distance; they do collect water and accumulate moisture, and are sometimes filled with surprisingly lush vegetation in the early spring. They offer no serious constructional difficulties.

When the line approaches Trans-Jordan at about MP 860 it enters the well-known Trans-Jordan lava beds. Road construction here is moderately difficult. The lava beds themselves are quite different from what one might believe from looking at the maps or from a casual examination. Much of the lava has weathered into a yellow sand, but there are large boulders covering almost the entire surface. Below the surface there is a mixture of sand and boulders. A fair road can be made by sweeping away the surface boulders, provided enough binding material can be brought in to stabilize the sand and keep it from blowing away. The subsurface boulders, however, make ditching operations difficult.

Beyond the lava beds the right of way enters country which becomes more and more built-up. Occasional settlements and villages with permanent structures come into evidence. Flowing streams develop, and patches of soil, carefully terraced and intensively cultivated, are interspersed with rocky hills. Beyond the lava beds the right of way skirts the Jebel Druse, a volcanic butte which is a landmark for miles around, and finally drops into the valley above Lake Hula.

There is one other interesting type of country that a pipe line must cross in eastern Arabia, and that is the salt bogs known as "sabkhas." They are permanently wet and often have an almost absolutely flat surface, giving one the impression that they are natural pools of salty water that have blown full of sand, finally forming a stable surface just damp enough and smooth enough to prevent more dry sand from adhering. Indeed, that is what they are. Sometimes the surface of a sabkha is covered with loose sand of varying depth. They are always wet under the surface, and the crust may be anything from damp to very dry, depending on the location and the season of the year. Sabkhas are all confined to the general vicinity of the Gulf Coast, but the pipe line crosses several of them, some of which are fairly large. They are treacherous for automobile and truck transportation, but a good road can be constructed by proper grading and by bringing in some outside material.

While only the western part of the terrain is mountainous in the sense usually understood, some of it has prompted design features that have not usually been used in the construction of oil pipe lines. Where the line crosses moving dunes it has, in general, been buried. Of course the dunes were avoided in so far as possible, and a good deal of work was done in moving sand to put the pipe in as stable a situation as possible, but it will have to be watched and perhaps readjusted as the sand moves. Across sabkhas the line is supported on steel piles. The piles have I-beam caps, and the pipe is held in pressed-steel ring girders. Across stable dikaka (dikaka is the local name for stable sand covered by small thorny bushes) the pipe line is and will be buried. It will also be buried across the gravel plains where reasonable excavation by ditching machine is possible. Across rock plains three different methods of construction will be used, depending on the depth of the rock below the surface. Where the rock is deep enough to permit the line to be buried, this construction will probably be used in most cases. Where the rock is on the order of two feet below the surface, it is proposed to lay the pipe on a well-padded support after excavating down as far as the rock, and then to mound up soil over the line to hold it in place. This second type of construction will not suffice to anchor the line, and at horizontal changes in direction or vertical overbends an anchorage will have to be provided. Where the rock is close to the surface or on the surface the line will be supported a few inches above the ground at intervals of

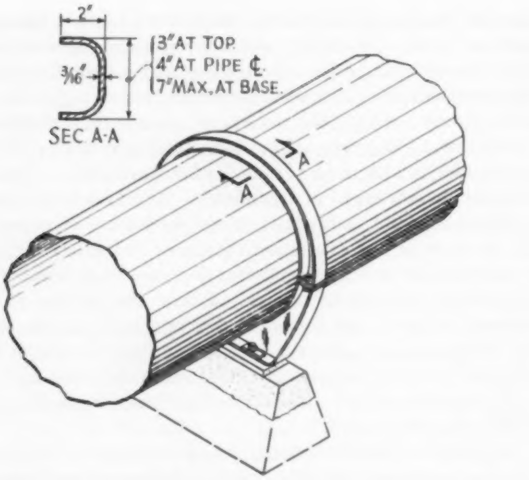

FIG. 2 PRESSED-STEEL RING-GIRDER SUPPORT FOR 30-IN-DIAM PIPE LINE

20 meters (about 66 ft) in pressed-steel ring girders supported on small concrete pads, see Fig. 2.

The above-ground construction is of principal technical interest since the other types of pipe-line construction are well understood. In so far as the supports are concerned, after quite a bit of study of the secondary stresses at supports it became evident that it would be necessary to reinforce the pipe at these points in some manner, and pressed-steel ring girders, as indicated in Fig. 2, were selected as the most economical method of reinforcement, being light, and in large quantities, fairly inexpensive. Static bending movements are maximum at the supports, but are only moderate at a 66-ft spacing.

A second problem was that of temperature. Expansion joints were considered virtually out of the question. Expansion loops were considered, and, in fact, had been used in smaller lines in Arabia and elsewhere. They are very expensive in such large-size pipe, and increase the length by several per cent besides introducing extra fluid friction. Moreover, careful analysis, including frictional effects, shows that they do not reduce the net temperature stress in a large line unless spaced close together. A still further objection to such expansion provisions is that each one of the ring-girder supports would not only have to have a sliding plate or equivalent on its foundation, but would also have to be guided laterally.

Still another method of construction considered was that of laying the line in a zigzag fashion so that it could increase or decrease its length by moving laterally. This type of construction has been used successfully by the Anglo-Iranian Oil Company on small lines for a considerable period of time, and was also used on the land sections of a 12-in. line which was laid between the east coast of Arabia and the refinery on Bahrein. The zigzag construction is fairly easy to accomplish in the case of a small line not requiring reinforcements at the supports, but in the case of a large line it would again introduce serious secondary stresses and mechanical problems. A large line of thin-wall section has much more dead weight per foot in comparison to the amount of metal than a small line, and hence friction on supports is so magnified as to make expansion provisions comparatively ineffective unless expensive antifriction supports are employed.

A careful study based on these considerations indicated that the pipe line would be under no more net stress if no attempt was made to permit expansion and contraction, but if, instead, it was simply held rigidly in place, of course being suitably anchored at changes in direction. In this study it was assumed that the pipe might reach a temperature 30 deg higher than the atmosphere, or, in other words, a maximum of 140 F. (The first part of the line will be operated at 160 F maximum, the hot oil coming from a crude-oil stabilizer.) The temperature of installation was assumed to average 80 or 90 F—less during winter—and the minimum temperature reached by the flowing oil probably not less than 40 F, although atmospheric temperatures in western Arabia often go below freezing. In other words, it was necessary to figure on a range of about 100 deg in temperature, perhaps two thirds or more of which might be in one direction. Every degree change in the temperature of a completely restrained piece of steel results in an axial stress of approximately 190 psi, so 70 deg would result in an axial stress of about 14,000 psi which, it was believed, was not excessive in view of the fact that the circumferential tensile stresses were more than double this amount. Of course the column stability of the line on supports at 66 ft was verified.

In addition to the axial stress due to temperature, there is also that due to internal fluid pressure. The latter is tension and amounts to 30 per cent of the circumferential stress instead of the 50 per cent that it would be with a free-floating line closed at the ends. This tension tends to offset the compressive stress due to rise in temperature in the more highly stressed portion of the line, and it appeared to the designers that it would, if anything, be helpful. There was a good deal of discussion regarding the calculation of the effect of combined stresses by the maximum-shear theory of elastic failure. The latter was discarded (or at least ignored) since there did not seem to be any evident mechanism by which a complete failure in shear could take place in a structure of this kind, nor any probability that shear at an angle to the axis when the pipe was in compression could operate to induce a premature failure of either the longitudinal or circumferential welds. This, however, is a question where discussion would be welcome. The two types of failure ordinarily encountered in a pipe line are rupture of the longitudinal weld almost invariably as the result of inherent defects, or, second, having the line pull apart as the result of tension of circumferential welds made in the field. The latter type of failure would of course not be expected when the line was in compression.

Fig. 3 shows the above-ground construction of the line on piles across a sabkha.

Still another problem considered was vibrations caused by the wind. The Kármán effect for isolated structures removed from sources of interference whereby eddies detach themselves alternately from two sides of the cylinder was considered, but no conclusion could be drawn since there appeared to be no available information whatever concerning the Kármán effect on a cylinder laid horizontally and relatively close to the ground.

There is plenty of wind in Arabia, and during the so-called shamal (shamal means north in Arabic, and that is where the wind usually comes from) period it may blow at 30 mph for days at a time. The natural period of vibration of a 30-in. pipe line filled with oil and laid across 20-meter supports is about 2.6 cycles per sec. The Kármán effect supposedly disappears from 30-in. isolated cylinders at a wind velocity of about 20 mph, at which time its exciting frequency is estimated to be between 2 and 3 cycles per sec. It was realized that this result could not be applied to a pipe line close to the ground and the decision was to lay the first part of the line, see what happened, and then do something about it if it proved to be necessary.

Up to now the line has shown some vibration, but the deflections have amounted to no more than about $^1/_2$ in. by actual measurement, although offhand guesses have almost always

FIG. 3 ABOVE-GROUND CONSTRUCTION OF 30-IN. PIPE LINE ON PILES

been greater. There has been no evidence of resonance at any wind velocity so far encountered, but there has been some evidence that the line goes into free vibrations of fairly small amplitude at its natural frequency at certain times, perhaps after receiving a shock excitation from gusty or variable wind.

Precautions were taken to free-up adjacent sections of the line before welding them together, and it was decided that full-strength anchors should be installed at intervals of about 2000 meters.

It is estimated that about 350 miles out of 1067 will be laid above ground, and that the rest will be either partially or completely buried.

The portion of the pipe line that is buried will be wrapped, and cathodic protection applied where it seems warranted. The wrapping so far applied consists of a primer, a heavy coat of asphalt, a wrap of glass fabric, a second coat of asphalt, and finally an exterior wrap of asbestos fabric. In addition, the bottom of the ditch is covered with a fabric padding to minimize the hazard of having the coating damaged before the backfill is complete. The results so far obtained with this type of coating have been very promising. Most of it so far has been installed in the dikaka country where the sand is stable and has a high electrical resistance, and where damp, salty, low-resistance soil can be reached by excavating 10 to 20 ft. Under these favorable circumstances, a single magnesium anode dropped into the salty material has in several instances depressed the electrical potential of the pipe more than a volt for 10 or 15 miles.

It is fully realized of course that this extremely favorable situation will not exist in the more easterly parts of the line, and it is, in fact, expected that suitable low-resistance spots for anodes may be difficult to obtain, and that most of the protection may have to be supplied by magnesium ribbon and by anodes in deep wells at the station sites where plenty of power is available. Nevertheless, the high initial resistance of the wrapped coating so far applied furnishes a strong basis for the belief that, with a little care, corrosion of the buried sections of this pipe line can be virtually prevented.

The pumping stations on the Trans-Arabian Pipe Line are of interest mainly because of their large size rather than any unusual features or departures from ordinary practice.

Station No. 1 contains two 6000-hp steam turbines directly coupled to two-stage centrifugal pumps, each capable of delivering about 340,000 bpd against a maximum of 840 lb pressure. The exhaust from these turbines will, under normal circumstances, be used for heating in a stabilizer which removes hydrogen sulphide from the crude oil, but it can be alternately routed to dry air-blown condensers in case operation of the stabilizer does not parallel pumping requirements.

The pumps at Station No. 1 are of conventional design, although they are perhaps the largest units of their type ever built—2-stage, double-volute type, 340,000-bpd, 840-psi, 3600-rpm, 87 per cent efficiency.

Stations 2 to 6 inclusive will operate with single-stage centrifugal pumps in series. The pumps are driven by 1700-hp Diesel engines through speed-up gears. The pumps operate at a nominal 2200 rpm and the engines at 343 rpm. The engines are of the 4-cycle type, supercharged by the Elliott Buchi system. They have 8 cylinders, 16-in. bore × 20-in. stroke, and are capable of operating at a bmep of 120 psi. There will be five pumps in series, four normally operating to meet the requirements of the line and one spare. The individual pumps are by-passed with lines containing check valves and of course have motor-operated suction and discharge valves. Any unit can therefore be started and stopped without disturbing other units.

Besides the main driving units for the pumps, there will be three electric generators, one a spare, for driving auxiliaries, including the fans of the extended-surface dry air-blown radiators that will cool the jacket water and the lubricating oil. They will supply power for all incidental uses, including air cooling of the living quarters and refrigeration.

The stations are piped in such a manner that they can be operated either straight-through with "closed suction" or by floating a 96,000-bbl tank on the line coming into the station.

The Mediterranean terminus of the Trans-Arabian Pipe Line will be a few miles south of Sidon at a point where the Zahrani River empties into the Mediterranean. It is planned to install 16 tanks of 180,000-bbl capacity, each at elevations 285 to 378 ft above the water. The tanks will be about 5200 to 7200 ft from the shore. Four submarine loading lines will extend some 2700 ft from the beach to a point where the water is 50 to 55 ft deep, and in addition there will be separate ballast lines. The initial installation will probably be the simplest necessary for loading tankers by gravity with crude oil at a high rate, although the possibility of a refinery at this point at some later date has always been borne in mind. Incidental facilities required for a submarine loading terminal are a separator for handling oily ballast, a communication system from ship to shore and from shore to tankage for controlling flow of oil, and a small pier for the launches that are necessary for handling ships' mooring lines, transferring personnel, and moving minor supplies.

The design of the facilities at Sidon has not been entirely completed at the time this paper is written, but probably there will be four 30-in. lines from the tankage to the beach where there will be a manifold and then four 30-in. submarine lines.

The Trans-Arabian Pipe Line Company and their staff have extended every possible assistance in the preparation of this paper, and they are to be commended for the candor with which they have supplied information concerning some of their engineering and construction difficulties, as well as their generally well-thought-out and successful program for design and construction.

The UNION *and the* ENGINEER

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In what follows, I do not propose to argue the case for or against labor unions or the over-all objectives of labor laws. Nor do I propose to embark on a crusade for or against activities of engineering employees in the field of collective bargaining. Having found myself, through no choice of my own, in the thick of the controversy about what course professional employees should pursue under administration of the country's labor-relations laws, I have accumulated some degree of familiarity with the situation. It is my hope to present, in objective fashion, a review of what has been going on and to indicate why the national engineering societies have deemed it incumbent on them to take an active interest in what has transpired. Naturally, my observations will be flavored with the point of view developed within my own Society, the American Society of Civil Engineers.

THE DEVELOPMENT OF COLLECTIVE BARGAINING

One of the fundamental reasons—perhaps the chief one—for the existence of labor unions is to develop effective means for establishing agreements between union members and their employers to further what employees believe to be their best interests in such matters as working conditions, hours of work, and compensation.

Even a casual study of employment conditions which existed generally throughout our industries in past generations indicates that there was obvious need for improvement. So long as each individual laborer was left to shift for himself in trying to obtain a fair share of the fruits of his labor, his progress was slow and, unfortunately, results were discouraging. Hence there came the development of labor unions dedicated to the purpose of handling problems common to their members on a basis of group action. Representatives acting in behalf of an entire employee group sought opportunity to bargain with employers to arrive at resolution of their difficulties, and thus there came about what now is recognized as collective bargaining in connection with relations between employers and employees.

Collective-bargaining processes began in the United States more than a century ago, although Samuel Gompers is reputed to have introduced the term "collective bargaining" in connection with employer-employee relationships. As far back as the 1820's, there were a few local unions. However, their activity was sporadic and rather desultory. There was no statutory regulation.

In 1881 the American Federation of Labor (AFL) was established and unionism began to expand more rapidly. Approximately at the turn of the century, came another incentive for unionization—the advent of mass production on a large scale.

The techniques of mass production brought increasingly large industrial organizations and with them a major change in methods of management. The one-time shop or factory in which the owner was the manager and the boss of ten, twenty, or perhaps a hundred employees, gave way to industrial organizations owned by thousands of stockholders and requiring thousands of workers, with a board of directors and salaried management interposed to direct operations. Individual employees lost their identity to a large extent and completely lost direct contact with the owners.

These factors, coupled with the use of automatic machinery, standardization of products, and standardization of labor processes, presented what appeared to union leaders added need for regulating the performance of labor in such matters as hours of work, quantity of production, working conditions, and wages, and they were not slow in stepping into the field.

So came further expansion and with it inauguration of vertical unions in the new industries. In general, AFL unions had been based upon the crafts, each composed of members having common interests by reason of the particular skills and working conditions incident to their jobs. On the contrary, the vertical union aims toward company-wide, or even industry-wide, coverage as exemplified in the Congress of Industrial Organizations (CIO). The chief mutuality of interest among members of a company-wide union lies in the circumstance of having a common employer and a common place of employment. Obviously, such a group may contain employees with wide divergencies of skills and interests. The resulting heterogeneity became one of the principal aggravations in the dilemma of professional employees later on.

In the 1920's and 1930's, statutory protection of labor unions developed and this gave them further encouragement. Passage of the Wagner Act, in 1935, provided the crowning stimulus, and the unions grew apace, until today there are something like sixteen million dues-paying members in recognized trade unions.

A semblance of legal recognition of collective bargaining appeared during World War I with establishment of the War Labor Board. However, the Railway Labor Act of 1926 was the first federal law to assert the right of labor to organize without interference. Although the law applied only to one industry, it was the beginning of statutory guarantee. Six years later came the Norris - La Guardia Anti-Injunction Act which also recognized the right of labor to organize and bargain collectively, although there were no teeth in its provisions. In 1933 the National Industrial Recovery Act was added to the growing list.

It remained for the National Labor Relations Act of 1935 (Wagner Act) to provide full-blown guarantee of the right of labor to organize and bargain collectively and to protect labor unions against specified "unfair labor practices" on the part of employers. That Act continued in force without change until 1947, when the Labor-Management Relations Act, 1947 (Taft-Hartley Act), substantially modified its provisions in a number of important respects. In spite of assertions by labor leaders that the latter was designed to sound the death knell of labor unions and their collective-bargaining rights, the unions have continued to grow, and collective bargaining, in most instances, seems to have proceeded in more orderly fashion than before.

All these labor laws have been directed toward improving the status of "employees," and professional employees are just as much subject to their provisions as any others. Supposedly, professional employees have had the same privileges as others, and they have been subject to rulings of the National Labor Relations Board, frequently to their distress.

Prior to passage of the Taft-Hartley Act, the Wagner Act was the most important of the labor laws, especially to pro-

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An address delivered at the Annual Meeting, Troy, N. Y., June 20–24, 1949, of the American Society for Engineering Education.

fessional engineers. It was the purpose of the Wagner Act to guarantee to employees "the right to self-organization, to form, join, or assist labor organizations to bargain collectively through representatives of their own choosing, and to engage in concerted activities for the purpose of collective bargaining, or for mutual aid and protection."

The Wagner Act was drawn with the avowed purpose of favoring labor in its relations with management. As time passed it became very obvious that labor pressed its legalized advantages so far as to be harmful to the public interest in some important respects. Whereas at one time management was inclined to ride roughshod over labor, the pendulum swung too far in the other direction. The Wagner Act permitted labor by law to ride roughshod over management. One condition was as vicious as the other, and the general public was the loser either way. It was long evident before 1947, that steps should be taken to bring the situation into better balance with more equitable legislation which would require both labor and management to assume their proper shares of responsibility in solving the problems of labor relations.

It is a constitutional right of any employee to unite with others if he desires to do so in the furtherance of legitimate objectives. But bargaining on labor conditions should be bargaining. Intimidation, coercion, property destruction, and boycotting have no place as "rights" of anyone to be used as weapons to enforce the will of employer or employee. The brutal and destructive practices followed in recent years by some labor groups were not the exercise of constitutional rights but were flagrant denial of them.

THE PLIGHT OF ENGINEERS UNDER THE WAGNER ACT

For many years, labor unions contented themselves with efforts to organize the trades and common labor. However, in 1918, the AFL amalgamated a group of technicians and subprofessional men into the International Federation of Technical Engineers, Architects, and Draftsmen's Unions (IFTEA and DU). In 1933 a group of independent unions of technicians organized the Federation of Architects, Engineers, Chemists and Technicians (FAECT) and affiliated with the CIO. Later, it was absorbed into the United Office and Professional Workers of America, CIO. It is estimated that the two organizations now may have a combined membership of some 20,000. Although they have some professional members, they are heterogeneous in character. Some smaller organizations also entered the ranks of professional and subprofessional employees.

It was not impossible for a group of professional employees to form their own bargaining organization under the Wagner Act, but such action was complicated and difficult. As a result of the Act and interpretations and decisions of the National Labor Relations Board, professional engineers were required, in some instances, to join unions composed almost wholly of nonprofessional employees in the manual trades in order to hold their jobs. Other situations developed in which professional engineers found their collective-bargaining right being claimed by unions with which they did not wish to be affiliated.

One of the best examples of what could happen is found in the case of the Shell Development Company, Inc., at Emery, Calif. In the early 1940's, 201 professional men, largely chemists, among whom were 44 with the degree of Doctor of Philosophy, found themselves about to be forced into a heterogeneous bargaining unit with a slightly larger number of nonprofessional employees. Among the latter were considerable numbers of roustabouts, janitors, window washers, and the like. Quite appropriately, the professionals raised violent objection and a long-contested struggle ensued. With financial and legal assistance from the American Chemical Society, the case was fought to a finish before the National Labor Relations Board, with the fortunate result that the professional men succeeded in gaining recognition for an organization of their own and were able to stand by themselves.

A notorious situation arose at the Bloomfield, N. J., plant of Westinghouse Electric Corporation, where professional engineering employees were included in a heterogeneous group. Among other distressing developments, they were compelled to go out on strike, and their protests brought threats of reprisals. In spite of a petition for withdrawal, the National Labor Relations Board refused to grant their request for a separate unit under the Wagner Act. It was not until the Taft-Hartley Act opened the way that they finally succeeded in getting out of their predicament.

Such unfortunate circumstances were discouraging. There was definite need for engineers to be concerned about what went on in those years under the Wagner Act. The professional man does not fit into the kind of organization or modus operandi of most labor unions. The attitudes, abilities, and work characteristics of a professional man just are not susceptible of standardization and regimentation in accordance with labor-union criteria. It is a fundamental of labor-union principles that quantity of work and compensation shall be standardized. This means that all, whether expert or inept, must be held to some standard of production, and, obviously, the standard must be at a low or mediocre level if it is to be within reasonable reach of all. Quite to the contrary, the aim of professionalism is superiority of production. It is folly to attempt standardization of the genius and abilities of creative artists or of professional engineers in the conduct of their professional work. Whatever merit labor-union principles may have with reference to the performance and products of labor, they are not similarly applicable to professional services.

Regardless of idealism, the profession was faced with stern realities. Labor unions made increasing inroads on the ranks of professional employees during the years following enactment of the Wagner Act. The professionals were inept in the field of labor relations. Overwhelmed by the tactics of experienced union organizers and regardless of their wishes, they were likely to find themselves included in a heterogeneous bargaining unit almost before they were aware of what was going on. Once included, their protests usually were of no avail. Inevitably constituting a small minority in a large industrial organization, they were unable to choose their own representatives or to gain adequate opportunity to express their views. They became increasingly bewildered and discouraged. Evidence of the confusion was reflected by the number of disputes involving professional employees that came before the National Labor Relations Board.

It was natural for employee members to look to their national engineering societies for guidance, and there developed a swell of demand that something be done to help them out of their plight. But the field of labor relations was new to the professional societies. None knew what course to pursue, let alone how to pursue it. Some leaders in the profession advocated exemption for all professional employees, but it became evident that a very large number of employees did not want exemption. Even if desirable, such a program would have required amendment of the Wagner Act, and there was no likelihood of such an event in the early 1940's. One society went so far as to contemplate denying membership to any who took part in collective bargaining, but that program was abandoned when sober second thought indicated the manifest injustice that would have been inflicted on those who, frequently against their desires, had been included in bargaining units under rulings of the National Labor Relations Board.

Some valuable contributions resulted. The publication entitled "Technologists' Stake in the Wagner Act," produced by

the American Association of Engineers in 1944, gave a comprehensive record of experiences under the Act, set forth in detail an explanation of difficulties which had beset professional employees, and described steps necessary for the formation of appropriate collective-bargaining groups. The American Chemical Society contributed a major pioneering service in its support of professional employees in the Shell Development Company case to which reference has been made.

Events appear to have demonstrated that the American Society of Civil Engineers followed the most consistently constructive course. As far back as 1937 the Society appointed a Committee on Unionization whose function was to study the extent of unionization among engineers and recommend to the Board of Direction suitable courses of action. In 1941 the Society renamed its committee the Committee on Employment Conditions and broadened its scope of action. As a result of recommendations from this committee, based upon its survey of experiences of professional employees with labor-union organizations and after study of the legal aspects of collective bargaining, the Board decided, in 1943, to undertake a positive program to provide means for the development of "professional units." In essence, this was a purely defensive tactic.

Some opinion was held that the ultimate goal should be complete exemption of professional employees from coverage of the labor laws, but that did not prevail under the insistence of large numbers of employee members that they did not wish to be denied privileges granted to other employees. They wanted guidance in avoiding domination by labor unions and wanted to know how to exercise appropriately their privileges in employer-employee relationships.

Early in its deliberations, the Board of Direction (of ASCE) concluded that the most desirable long-range objective would be changes in the labor laws which would, at the very least, prohibit the forced inclusion of professional men in labor-dominated bargaining units and which would permit them to refrain from collective bargaining if they chose to do so. Unfortunately, that was a hopeless task prior to the 80th Congress. The immediate problem in 1943 was that of helping professional employees to meet their problems under the provisions of the Wagner Act.

The Society (ASCE) published a manual, "The Engineer and Collective Bargaining," in July, 1943, and later in the same year promulgated its suggested program.

Under the plan, preliminary steps of organization might be taken by a local section of the Society. In succeeding steps, Society participation became less and less, until, by the time a bargaining unit was created, the Society was entirely divorced from the proceedings. Not only was this procedure desired by the Society, it was a statutory requirement. Nothing is more fatal to recognition of a bargaining unit by the National Labor Relations Board than domination or influence by an employer, and since the Society is composed of both employers and employees, it is mandatory that it have no part in the functioning of a unit. The plan met with substantial success, as is attested by the fact that a number of professional engineering bargaining groups formed under its terms are currently in existence and functioning satisfactorily.

Looking forward hopefully to the time when there might be an opportunity to bring about amendment of the Wagner Act, the Society's Board of Direction adopted a statement of policy covering the principles deemed appropriate for the purpose. That policy was in three parts, as follows:

(1) Any group of professional employees, who have a community of interest and who wish to bargain collectively, should be guaranteed the right to form and administer their own bargaining unit and be permitted free choice of their representatives to negotiate with their employer.

(2) No professional employee, or group of employees, desiring to undertake collective bargaining with an employer, should be forced to affiliate with, or become members of, any bargaining group which includes nonprofessional employees, or to submit to representation by such a group or its designated agents.

(3) No professional employee should be forced, against his desires, to join any organization as a condition of his employment, or to sacrifice his right to individual personal relations with his employer in matters of employment conditions.

As early as 1946 these principles were presented in a statement on behalf of the Society to a Subcommittee of the House Labor Committee of the 79th Congress. That was late in the session and nothing resulted except the planting of the seed.

THE TAFT-HARTLEY ACT

Thus the American Society of Civil Engineers, as a result of some ten years of intensive study and firsthand experience with the problems involved and because it had adopted a definite policy, was in a position to provide the needed leadership toward amendment of the labor laws when opportunity presented itself during the first session of the 80th Congress.

Engineers Joint Council (EJC) had been giving attention to the problem. Through its Committee on the Economic Status of the Engineer, it had undertaken an intensive study of the whole field and published an excellent "Manual On Collective Bargaining For Professional Employees," in 1947. Council represents the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Chemical Engineers. The National Society of Professional Engineers (NSPE), although not a member of EJC, collaborated in preparation of the Manual.

In 1947 Engineers Joint Council adopted the before-stated principles as its official declaration of policy upon which to frame legislative provisions in the interests of professional employees. Council established a Labor Legislation Panel for the specific purpose of presenting the matter to Congress. The National Society of Professional Engineers and the American Society for Engineering Education were invited to participate, and each appointed a representative on the Panel.

Legislative bills based upon EJC's officially adopted principles were introduced in both Houses of Congress, the bills being so framed as to cover the interests of all professional employees, not engineers alone. The Panel testified in support of the amendments before labor committees of the Senate and House. The American Chemical Society collaborated and presented a statement of its own.

The effort was successful, as quotations from the Taft-Hartley Act shortly will demonstrate. Obviously, the first problem involved was that of providing a satisfactory definition of "professional employee." Without a statutory definition the National Labor Relations Board could have no firm basis upon which to determine whether or not an employee should be classed as professional. The lack of any differentiating definition in the Wagner Act was a real stumbling block in cases where the Board undertook to assign separate coverage for a bargaining unit of professional employees.

It was a source of real satisfaction to professional employees to have the following wording written in Section 2(12) of Public Law 101—80th Congress, which is officially known as the Labor-Management Relations Act, 1947, and commonly referred to as the Taft-Hartley Law:

(12) The term "professional employee" means—

(*a*) any employee engaged in work (i) predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work; (ii) involving the consistent exercise of discre-

tion and judgment in its performance; (iii) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (iv) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning or a hospital, as distinguished from a general academic education, or from an apprenticeship, or from training in the performance of routine mental, manual, or physical processes; or

(*b*) any employee, who (i) has completed the courses of specialized intellectual instruction and study described in clause (iv) of paragraph (*a*), and (ii) is performing related work under the supervision of a professional person to qualify himself to become a professional employee as defined in paragraph (*a*).

Section 9(*b*) establishes the principles under which professional employees are guaranteed the right to have units of their own if they care to do so. Following is a quotation from that section:

SEC. 9(*b*) The Board shall decide in each case whether, in order to assure to employees the fullest freedom in exercising the rights guaranteed by this Act, the unit appropriate for the purposes of collective bargaining shall be the employer unit, craft unit, plant unit, or subdivision thereof; PROVIDED, That the Board shall not (1) decide that any unit is appropriate for such purposes if such unit includes both professional employees and employees who are not professional employees unless a majority of such professional employees vote for inclusion in such unit;

The essence of this is that a group of professional employees in any place of employment may decide, by majority vote of their own numbers, whether they want to form a unit of their own for collective-bargaining purposes, to join with some other bargaining group, or to refrain from any action of the sort, if they so prefer. That is a far cry from the old Wagner Act conditions under which a group of laborers or production workers might form a collective-bargaining unit and a few unfortunate professional employees might find themselves forced to become members or quit their jobs. At last, professional employees had statutory protection.

PRESENT STATUS OF LABOR LEGISLATION

With the current (81st) Congress came a great hue and cry from the Democratic Administration for repeal of the Taft-Hartley Act. Legislative bills to that end which were introduced in both Houses of Congress omitted all reference to the status of professional employees. If this Administration-sponsored legislation were to be enacted, professional employees would be thrown back into the same sorry plight they were in under the Wagner Act.

Realizing the possibility of losing all of the ground gained, Engineers Joint Council, as before, took appropriate steps to present the viewpoint of professional employees to the Committees of Congress. The Labor Legislation Panel was reconstituted with instructions that every appropriate effort be made to retain the pertinent provisions of the Taft-Hartley Act. ASEE and NSPE again participated. The Panel presented statements before the Labor Committees of Congress and met with what appeared to be a sympathetic reception. Supporting testimony also was presented on behalf of independent bargaining groups of professional engineering employees. However, each Committee voted on strictly political lines and, since Democrats were in the majority, reported the respective Administration Bills to the Senate and the House exactly as they had been introduced.

Violent controversy has developed and there is question whether any conclusive action will be taken during the present session. Substantial support for the interests of professional employees exists in both Houses of Congress and there appears to be reasonable expectation that the pertinent provisions will be continued in whatever new legislation may be finally enacted.

DEVELOPMENTS UNDER THE TAFT-HARTLEY ACT

As a result of the Taft-Hartley Act, professional employees found themselves in a vastly improved situation. New opportunities were available, and with them, new responsibilities.

The stigma attached in the minds of professional people to collective-bargaining procedures developed between management and labor during recent years has tended to make the very term "collective bargaining" offensive. Destructive strikes, violent picketing, limitation of productive effort, and the like, are measures far removed from the type of bargaining to which a professional man might subscribe.

Of course, it is only by the accumulation of experience under the terms of the new law that we will be able, finally, to decide as to its full merit and as to the worth-while benefits that may accrue to professional employees under its administration. At first, some expressed fear that the Labor Relations Board would be lax in its determinations of professional status. Others predicted that employers would find opportunity to take undue advantage of professional employees because of the relatively small numbers in their bargaining units. Experience to date serves to discredit those fears.

It is to be noted that the provisions regarding professional employees are so written as to apply to all who may qualify under the definition of "professional employee." Already there have been cases of interest. One of the first had to do with a group of "time-study" employees of the Worthington Pump and Machinery Corporation of Holyoke, Mass. Although the National Labor Relations Board was split in opinion as to the appropriateness of certifying such employees, the majority ruled that they were entitled to a collective-bargaining unit of their own as professional employees.

In another case it was ruled that newspaper people—editors, rewrite men, and reporters—are not professional employees under the definition in the Act, inasmuch as they are not required to undergo specialized training in an institution of higher learning. Again, attorneys employed by the Lumbermen's Mutual Casualty Company of Chicago were recognized as professional employees by the NLRB and formed their own unit.

These are only a few of the many cases that have been brought before the Board, to date. Among the most interesting and significant have been requests for decertification by professional employees who had been included willy-nilly in heterogeneous groups under the Wagner Act and who, in some instances, had been unable to disentangle themselves in spite of determined effort. In several cases, such employees have succeeded in breaking away and now have their own units.

No dependable figure is available as to the number of professional engineering employees now included in collective-bargaining groups, although the total is estimated at some 18,000 or 20,000. Somewhat more than half of these are included in units certified by the NLRB.

Although the movement has become widespread, the greatest concentrations are to be found on the West Coast and in the Philadelphia-New Jersey area.

Prominent in the West are the following organizations:

Seattle Professional Engineering Employees Association.
Professional Engineer Employees Association of Eastern Washington.
Southwest Washington Association of Professional Engineering Employees.
Engineers Guild of Oregon.
Sacramento Group of Professional Engineering Employees.

San Francisco Group of Professional Employees.
Southern California Professional Engineering Association.

With a combined membership of some 3000, these groups have organized an inclusive National Professional Association of Engineers, Architects, and Scientists with the objective of co-ordinating their activities.

The Eastern Conference Committee of Independent Engineering Organizations is the co-ordinating body for six independent bargaining units. With a combined membership of over 5000, a majority are employees of the Western Electric Company in New Jersey. Others are in the employ of Sperry Gyroscope Company, Radio Corporation of America, General Electric Company, and Westinghouse Electric Corporation.

GENERAL COMMENT

It is doubtless true that most professional engineering employees never will have the slightest interest in collective bargaining, even under the Taft-Hartley Act. The young man who enters the modest-sized organization of a consulting engineering office probably will never give it a thought. It is not that sort of man about whom we are concerned. He has ready and close contact with his employer and no doubt would much prefer to depend solely upon his own abilities and initiative than submit to and be dependent largely upon group action for his advancement.

However, the situation is quite different in large industrial and manufacturing establishments. It is particularly the employees of such organizations that the societies had in mind when they advocated the professional-employee provisions of the Taft-Hartley Act. The rapid technological development of the country during the last two or three decades has been such that it is common to find hundreds of young scientists and engineer employees in one company. Obviously, there is not much opportunity for these men to maintain personal relations with their management. Experience has indicated that there are manifest advantages to both management and employees in a program which provides for full discussion between management and representatives chosen by the employees regarding problems of common concern. It appears that group action by professionals does have its place. What we are concerned about is that professional employees be permitted by statute to decide upon their own course without interference from others who have little understanding of their aims and standards.

It is earnestly to be hoped that whatever collective bargaining may be undertaken by engineer employees will be kept on a high plane. For action under the Taft-Hartley Act or any other law to be successful, or even tolerable, collective bargaining must be conducted in straightforward, dignified fashion, compatible with the ideals of professional people. Undue stratification of personnel, or regimentation of performance should be avoided. Initiative and ambition of individuals should not be stifled. Tactics which tend to build antagonisms between employers and employees should be deplored. It appears to be true that some of the engineering groups formed to date have conducted themselves appropriately and in a manner beneficial to both employers and employees. That is as it should be and if future activity is kept in the hands of good leaders, results can continue to be constructive.

The subject of employer-employee relationships in industry is one which well might be given increased attention in our institutions for engineering education. Too often, labor and management seem to have lost sight of the fact that they must have a common ultimate goal if their enterprises are to succeed. When either fails to realize that the expediency of gaining some immediate objective falls short of best serving the general welfare, both suffer in the long run. Employers and employees alike have obligations to themselves, to each other, and to the community.

This is a field which is highly appropriate for classroom instruction or for discussion on the programs of student chapters of the engineering societies. Our young engineers should not be launched on their careers without some understanding of the human relationships involved. They need to give thought to the justifiable aspirations of labor and to the prerogatives of management, and to realize that they will find themselves somewhere between the two with problems, opportunities, and responsibilities peculiar to their situation.

Professional Adjustments

IN a paper, "Professional Adjustments—A Challenge to the Young Engineer," which received honorable mention in a papers competition sponsored by the Junior Group of the Metropolitan Section of ASME, Glenn R. Fryling, Jun. ASME, assistant editor, Combustion Engineering—Superheater Co., Inc., New York, N. Y., urged that a course in "professional adjustments" be added to engineering curriculums.

Such a course would have to be flexible in content, sensitive to changes within the engineering profession, and adaptable to the needs of the students. The instructor should be one who is in close contact with industry and with the problems faced by young graduates. He might be assisted in his efforts by former students who could provide a continual interchange of experience linking theoretical college training to practical industrial application in matters of personal adjustment as well as in terms of technological problems.

The following list of subjects is suggested by Mr. Fryling as a basis for the course: (1) Guidance in obtaining employment, (2) professional registration, (3) labor-management relations affecting the young engineer, (4) professional-society organization and activity, (5) professional consciousness, (6) citizenship responsibility, (7) limitations of academic training, and (8) postgraduate education.

Many schools already provide guidance for students applying for industrial positions. However, in a professional-adjustments course that service might be extended to include consideration of techniques in seeking new employment.

Since registration of professional engineers is now required in all 48 states, it is an important factor that must be recognized by engineering education. Legal requirements of the state in which the institution is located should be explained, along with possible arrangements for reciprocity with other states.

The realistic problems of labor-union membership facing those entering industrial careers should be covered. There is no reason why this situation should be required to come as a surprise and a rude awakening to the young engineer. The instructor can explain objectively some of the problems to be faced and aid in the tentative evaluation of possible alternatives. He may also be able to solicit the aid of representatives from labor and management to present their viewpoints. Likewise, a study of current literature concerning labor relations, with particular reference to engineers, should be a part of the course. Attention should also be given to national and state legislation relating to unions and management.

A course in professional adjustments provides an opportunity to link formal academic training with professional engineering organizations.

In developing professional consciousness the student engineer should be made aware of the code of professional ethics adopted by the Engineers' Council for Professional Development and the major engineering societies.

The engineer also has responsibilities as a citizen, and colleges have a definite obligation to see that he is made aware of them.

EXPERIMENTAL AIDS *in* ENGINEERING DESIGN ANALYSIS

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THE equations of continuity and of equilibrium are fundamental in the analysis of many unrelated physical systems. As a result, differential equations of identical form appear in many different fields. The significance of this similarity in equations is twofold:

1 One may visualize the behavior of unfamiliar systems from a prior knowledge of the behavior of analogous familiar systems.

2 One may set up convenient and frequently relatively inexpensive experimental models which simulate the characteristics of the prototype without necessarily bearing any physical resemblance to it.

Thus many problems whose solutions are impractical by analytical or direct experimental means because of tremendous man-hour requirements, unreasonable costs, inaccessibility, nonexistence of an analytical approach, often are easily solved by means of the indirect, or analog, approach.

ENGINEERING PROBLEMS CHARACTERIZED BY PARTIAL DIFFERENTIAL EQUATIONS

In a two-dimensional continuum, which is characteristic of many physical problems, the condition of continuity leads to the Laplace equation

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0 \qquad [1]$$

where x and y are the independent variables, and ϕ is the dependent variable whose values are desired over the xy-plane.

This partial differential equation is of interest in machine-design problems in a number of applications. For example, in the torsion of uniform bars of noncircular cross section (1),[1] the shear-stress components are given by

$$\tau_{xz} = \frac{\partial\phi}{\partial y}, \quad \tau_{yz} = -\frac{\partial\phi}{\partial x} \qquad [2]$$

where ϕ is a "stress function" satisfying the equation

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = -2G\theta \qquad [3]$$

in which θ is the twist per unit length of bar, and G is the shear modulus of the bar material.

At the boundary of the cross section, ϕ must have a constant value (1), which may be taken equal to zero for a solid section.

If the function ϕ_1 is defined by the equation

$$\phi_1 = \phi + \frac{G\theta}{2}(x^2 + y^2) \qquad [4]$$

substitution of Equation [4] into Equation [3] results in

$$\frac{\partial^2\phi_1}{\partial x^2} + \frac{\partial^2\phi_1}{\partial y^2} = 0 \qquad [5]$$

subject to the boundary condition

$$\phi_{1b} = \frac{G\theta}{2}(x_b^2 + y_b^2) \qquad [6]$$

where x_b and y_b are co-ordinates of points on the boundary of the cross section.

The problem, then, is to determine either ϕ so that Equation [3] and the boundary condition $\phi = 0$ are satisfied, or to determine ϕ_1 so that Equation [5] and the boundary condition Equation [6] are satisfied. Knowing the distribution of ϕ from either approach, the torsional-stress distribution over the cross section may then be obtained from Equation [2].

Analytically this solution is likely to get cumbersome and time-consuming when irregular cross sections, e.g., a twist-drill section, are involved. Direct experiment is also not feasible because the usual strain-indicating devices cover too much surface area and are unable to reach interior points. It will be shown in the next section how analogies can readily solve this problem experimentally.

Another important torsional problem in machine design is that of determining stress concentrations in circular stepped or circumferentially grooved shafts under torque loads (2). Denoting by ψ the angle through which a circular-ring element of radius r in a cross section distant x from a reference cross section has rotated under load with respect to the reference cross section, the distribution of ψ throughout the twisted shaft must be such as to satisfy the partial differential equation

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial r^2} + \frac{3}{r}\frac{\partial\psi}{\partial r} = 0 \qquad [7]$$

The shear stress at the shaft surface is given by

$$\tau_s = Gr_s\frac{d\psi}{ds} \qquad [8]$$

where s is taken along a surface element.

The analytical solution of this equation for a stepped or grooved shaft is very laborious. An electrical analog, however, may be readily adapted to an experimental solution of this problem. This will be discussed in the next section.

A solution to Laplace's equation is potentially of considerable help in connection with photoelastic-stress studies (3). It is well known that the fringe pattern appearing in a photoelastic test shows the variation in principal stress difference $(P - Q)$, throughout the model. To separate the principal stresses, the variation in thickness of the model is measured, from which the principal stress sum is determined. The measurement of thickness is an exacting procedure, requiring precise instrumentation and considerable patience. By virtue of

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

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the fact that the sum of the principal stresses $(P+Q)$ must satisfy the relation

$$\frac{\partial^2(P+Q)}{\partial x^2} + \frac{\partial^2(P+Q)}{\partial y^2} = 0 \qquad [9]$$

the methods indicated in the foregoing for the solution of the torsional problem for uniform bars may be applied to this case as well.

Frequently a designer has occasion to require the steady-state temperature distribution in a solid subjected to specified boundary temperatures. Such a temperature distribution is determined by Laplace's equation

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0 \qquad [10]$$

and by the boundary conditions. When the area is of irregular shape or is subjected to a highly nonuniform temperature distribution around its boundaries, the analytical solution of Equation [10] is likely to be impractical. However, its experimental solution by means of an analogy can be as readily made as in the other problems involving Laplace's equation.

When heat conduction in three dimensions is involved, as is frequently the case, the temperature distribution must satisfy the Laplace equation

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} = 0 \qquad [11]$$

Here again an analogy provides a ready experimental method for solving an otherwise intractable problem.

Equations [10] and [11] were derived on the basis of a constant value of thermal conductivity throughout the body. This is not always the case, as the thermal conductivity is often a function of temperature. In such a case Equation [10] becomes

$$\frac{\partial}{\partial x}\left(k\,\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k\,\frac{\partial T}{\partial y}\right) = 0 \qquad [12]$$

A variable conductivity complicates considerably the analytical solution. It also prolongs the experimental solution by means of an analogy. Nevertheless, the analogy method is relatively easy to apply and will be discussed in the next section.

In problems involving transient heat flow, as, for example, in flash-welding, quenching, etc., Laplace's equation transforms into the diffusion equation

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = \frac{1}{b^2}\,\frac{\partial T}{\partial t} \qquad [13]$$

where $b^2 (= k/c\rho)$ is the thermal diffusivity of the material. Here again insurmountable difficulties are likely to occur in an attempted analytical solution of any but the simplest practical cases. By means of an analogy, however, solutions are readily obtained even in complex cases.

Where the flow of an ideal incompressible fluid around obstacles is concerned, the velocity potential ϕ, and the stream function ψ must both satisfy Laplace's equation

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0 \qquad [14]$$

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0 \qquad [15]$$

The x and y-components of fluid velocity, u and v, are given by

$$u = \frac{\partial \phi}{\partial x}, \quad v = \frac{\partial \phi}{\partial y} \qquad [16]$$

$$u = \frac{\partial \psi}{\partial y}, \quad v = -\frac{\partial \psi}{\partial x} \qquad [17]$$

The curves of constant ϕ and ψ comprise a network of orthogonal lines over the area of the flowing fluid. The lines of constant ψ are the streamlines of the flow. Both families of curves are conveniently determined experimentally by means of an analogy.

In the case of compressible fluid flow the velocity potential must satisfy the equation

$$\frac{\partial}{\partial x}\left(\rho\,\frac{\partial \phi}{\partial x}\right) + \frac{\partial}{\partial y}\left(\rho\,\frac{\partial \phi}{\partial y}\right) = 0 \qquad [18]$$

where ρ is the fluid density and is variable. This equation corresponds to Equation [12] for heat conduction with variable conductivity and may be solved by the same methods which will be discussed in the next section.

In predicting the ultimate production of an oil field (4), and evaluating the efficiency of water-flooding and gas-recycling (5) processes for displacing oil from an oil-bearing sand, information is required as to the expected progress of the water front or dry-gas front in the vicinity of producing wells. The flow of oil or high-pressure gas through consolidated sand is viscous, and, in the steady state, the pressure distribution must satisfy the Laplace equation

$$\frac{\partial^2 p}{\partial x^2} + \frac{\partial^2 p}{\partial y^2} = 0 \qquad [19]$$

The velocity of flow is given by the equations

$$u = -\frac{k}{\mu}\,\frac{\partial p}{\partial x}, \quad v = -\frac{k}{\mu}\,\frac{\partial p}{\partial y} \qquad [20]$$

where k is the sand permeability and μ the fluid viscosity.

Analytically, the solution to this problem for arbitrary input and output well configurations and oil-horizon shapes is impractical. An appropriate electrical analogy, however, will show visually the progress of the water or gas front. This case will be considered in the following section. Similar situations arise in the percolation of water through and under dams, and in flow through close-packed filters.

Another problem important to designers is that of oil flow and pressure distribution in journal bearings (6). This requires the solution of the Reynolds differential equation

$$\frac{\partial}{\partial x}\left(\delta^3\,\frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial z}\left(\delta^3\,\frac{\partial p}{\partial z}\right) = 6\mu U\,\frac{\partial \delta}{\partial x} \qquad [21]$$

where δ is the oil-film thickness, x the distance in the direction of motion, z the distance in the axial direction, U the relative velocity of the two bearing surfaces.

A direct analytical approach to the solution of this problem involves considerable difficulty. Experimental solutions by means of electrical analogy are obtained readily for a wide range of cases where side leakage, oil-feed locations, oil grooving, and partial bearings may be studied.

ANALOGY METHODS FOR EXPERIMENTAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS

Any experimental method which yields a solution to Laplace's equation subject to the prescribed boundary conditions, may be used for studying the various physical problems discussed in the previous section, in which Laplace's equation must be satisfied. For example, in the study of torsion of uniform bars of noncircular cross section, Equation [5], the soap-film analogy (7) has been used extensively.

When a soap film is stretched over an opening in a sheet of metal, the sheet having been so deformed that the vertical dis-

tance z from a horizontal reference plane to points on the edge of the hole varies from point to point in a predetermined fashion, the vertical distance from this plane to all other points on the soap film must satisfy the Laplace equation

$$\frac{\partial^2 z}{\partial x^2} + \frac{\partial^2 z}{\partial y^2} = 0 \qquad [22]$$

Thus if the projected area of the opening on the horizontal plane is made geometrically similar to the cross-sectional area of the bar in torsion, and if the vertical positions of points along the edge of the hole satisfy the boundary conditions given by Equation [6], then the values of ϕ_1 and z in Equations [5] and [6] will correspond. Although references in literature appear to be confined to the use of soap films in torsion problems only, evidently they may be used as well for the photoelastic problem, Equation [9], the temperature-distribution problem, Equation [10], the fluid-flow problem, Equations [14] and [15], and the oil-reservoir problem, Equation [19].[2]

However, the use of the soap film is not very convenient. It requires considerable patience and care, and is subject to various operational difficulties. A search for another experimental approach well might lead to the electric-current-flow analogy.

If a thin conducting sheet is subjected to a voltage distribution around its edges, the voltage distribution throughout the conducting sheet must satisfy the Laplace equation

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = 0 \qquad [23]$$

Thus if the area of the electrically conducting sheet is made geometrically similar to the cross-sectional area of the bar under torsion, and if the voltages imposed around the edges of this sheet are proportional to the values of ϕ_{1b} given by Equation [6], then the values of V throughout the area of the sheet will be proportional to the values of ϕ_1 over the area of the bar cross section. The conducting sheet may be used for all the problems considered in the case of the soap-film analogy. It has been used (8) to determine temperature distributions in the composite walls of a two-story building. The conducting sheet was metalized paper cut to full scale.

The conducting sheet need not be metal, however. In many cases a shallow pool of electrolyte forms a very flexible and accurately controllable conducting sheet obeying Equation [23]. Tap water usually serves as an excellent electrolyte for this purpose. The liquid must be contained in a nonconducting vessel whose area is large compared with its depth. The geometrical similarity of the bath area to the area of the prototype must be maintained. Electrodes situated around the boundary of the bath are subjected to a voltage distribution proportional to values of the dependent variable in the phenomenon under investigation. A probe moved from point to point in the liquid serves to plot the voltage distribution, or may be used to obtain voltage gradients directly if two closely spaced electrodes are used in the probe. Whereas with the metal-sheet model direct current may be used, in an electrolytic bath direct current results in polarization at the electrodes and resultant impairment in potential distribution. By using alternating current, this difficulty is substantially eliminated. In practice, electrolytic baths are almost invariably operated on alternating current.

Bradfield, Hooker, and Southwell (9) have used the electrolytic tank in the problem of torsion of a bar of triangular cross section. In heat conduction, perhaps the original work was done by Langmuir, Adams, and Meikle (10), in obtaining shape factors for corners, using an electrolytic bath. For tracing streamlines in incompressible flow of an ideal fluid, Relf (11) used a large tank (5 ft × 2 ft 6 in. × 1 ft 3 in. deep) filled with tap water. Malavard (12) describes a French laboratory for the study of various aerodynamical problems by means of electrolytic tanks.

In oil-recovery problems, the progress of a water or gas front through an oil horizon is observed by following visually the movement of ions in an electrolyte representing the oil horizon. These ions will have a velocity whose magnitude is proportional to the voltage gradient. The movement of these ions then is analogous to the movement of particles of oil under a pressure gradient in accordance with Equations [19] and [20]. The electrolyte is held in a gelatin medium to prevent diffusion and excessive ion velocities. The gelatin sheet is thin, of the order of $^1/_{16}$ in. in thickness; its plan form corresponds to that of the oil horizon, with electrodes spotted at positions in the gelatin sheet corresponding to the well locations in the oil field. Wyckoff, Botset, and Muskat (4) used phenolphthalein in the electrolyte as an indicator. The application of a direct-current potential between electrodes, representing output well and water drive pressure, caused a movement of OH ions from the negative electrode toward the positive electrode with resultant change in color of the ion indicator from colorless to red. The encroachment of water into the oil field is then observed as a slowly progressing red area. More recently, Botset (13) used ions of different color to represent the two different fluids—a a copper-ammonium ion, which is blue, and a zinc-ammonium ion, which is colorless.

The use of the electrolytic bath has a considerable advantage in the study of systems having variable properties. If the tank is made of variable depth h, the potential distribution obeys the equation

$$\frac{\partial}{\partial x}\left(h\frac{\partial V}{\partial x}\right) + \frac{\partial}{\partial y}\left(h\frac{\partial V}{\partial y}\right) = 0 \qquad [24]$$

Equation [24] corresponds exactly to Equation [12] for heat conduction in a solid of variable thermal conductivity, and to Equation [18] for the flow of a compressible fluid. In this application, the tank may be made with a heavy wax bottom (14), and a uniform layer of electrolyte may be used to determine the first approximation to the temperature or velocity distribution. This first approximation is then used to adjust the depth of the electrolyte by carving the wax bottom. A second approximation to the temperature or velocity is then determined and a further adjustment of tank depth is made on this basis. The process may be continued until the required degree of accuracy is attained.

By using a thin sheet conductor of variable thickness or an electrolytic tank of variable depth, certain axially symmetrical problems in stress and fluid flow are solved readily. For example, Jacobsen (2) used a steel "razor-blade" conductor to determine torsional-stress-concentration-form factors in a filleted circular shaft. By making $h \propto y^3$, Equation [24] becomes

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{3}{y}\frac{\partial V}{\partial y} = 0 \qquad [25]$$

Comparing Equation [25] with Equation [7], the analogy between ψ and V is evident. The co-ordinates x and y of the thin conducting sheet correspond to the co-ordinates x and r of the shaft. The edge of zero thickness of the conductor corresponds to the center line of the shaft.

Malavard (12) refers to the use of an electrolytic tank of variable depth for the study of axially symmetrical aerodynamic-flow problems.

Referring to the journal-lubrication problem, governed by Equation [21]; if in the electrolytic tank the depth is made proportional to the cube of the oil-film thickness, i.e., $h = k\delta^3$, and if at the same time a distributed current of density i is

[2] See note at end of paper.

fed into the tank over its entire area, then the equation for voltage distribution in the electrolyte becomes

$$\frac{\partial}{\partial x}\left(\delta^3 \frac{\partial V}{\partial x}\right) + \frac{\partial}{\partial y}\left(\delta^3 \frac{\partial V}{\partial y}\right) = \frac{ri}{k} \qquad [26]$$

where r is the resistivity of the electrolyte.

The analogy between Equations [21] and [26] is evident. It has been used by Kingsbury (15), by Needs (16), and by others (6), to determine pressure distributions, load capacity, and oil flow of various practical bearing configurations.

Convenient as the conducting-sheet analogies are in the solution of partial differential equations, in some cases considerably more flexibility and convenience are attained by using electrical-resistance networks. The resistance network, or lattice, gives an approximate solution to Laplace's equation just as does the numerical-network procedure developed by Liebmann (17). In the Liebmann numerical procedure, a network of squares is ruled over the area under consideration, e.g., over a drawing of the cross section of a noncircular bar in torsion. The values of the dependent variable are known on the boundary, e.g., Equation [6]. The values at the interior points are to be determined. The value of the dependent variable (Φ_0), at each network-intersection point inside the boundary is related to the values ($\Phi_1, \ldots \Phi_4$) at the four adjacent network-intersection points as follows

$$\Phi_0 = \frac{\Phi_1 + \Phi_2 + \Phi_3 + \Phi_4}{4} \qquad [27]$$

By assuming an initial distribution of values of Φ throughout the interior, and using the true values of Φ on the boundary, the value of Φ at each interior point may be corrected by the averaging process, Equation [27], so that by traversing the network over and over again, Equation [27] eventually will converge to a substantially stationary value at each point, thus providing an approximate solution to Laplace's equation. The accuracy of the method increases as the network is made finer, but the labor involved also increases very rapidly.

By replacing the lattice of lines by a lattice of equal electrical resistances, the solution may be obtained electrically merely by reading the equilibrium voltage at each node in the network. Voltages proportional to the boundary values of the dependent variable are applied at the resistance-network boundary points. Then the voltage at each interior point will be the average of the voltages at the four adjacent network points, which is exactly the result in Equation [27].

In laying down a network of squares over an area, the intersection points on the boundary, in general, will not be at the corners of squares, particularly when the boundaries are curved. Thus the distance from an interior point to adjacent boundary points may be less than the side of the square. The averaging procedure for such points is given by Shortley and Weller (18). Electrically, this averaging is accomplished automatically merely by making the values of the resistances near the boundary proportional to the lengths of the lines which they replace.

Thus the resistance network in many cases may replace the soap film, the thin-plate conductor, and the electrolytic tank in the solution of two-dimensional torsional, photoelastic, heat-transfer, ideal fluid-flow, and seepage problems. Moreover, for solving Laplace's equation in three dimensions, e.g., the heat-conduction equation, Equation [11], the lattice work may be made three-dimensional. This is an important advantage of the network.

A further advantage of the resistance network, which cannot be duplicated conveniently in any of the previous analogies, is the ease with which it may be adapted to the solution of the diffusion equation, Equation [13], for transient-heat conduction (19), or for unsteady oil flow in oil-bearing rock (20). The heat-storage capacity of a network square (or cube), and the oil-storage capacity of such an element in the oil-reservoir problem may be represented by an electrical capacitance of proportional magnitude connected to the corresponding network node on one side, and to the reference voltage (or ground) on the other.

The Columbia University "heat and mass flow analyzer" (21) is a calculating and simulating machine of the network type.

PROBLEMS CHARACTERIZED BY ORDINARY DIFFERENTIAL EQUATIONS AND THEIR SOLUTION BY ANALOGIES

An important class of problems invariably encountered in machine design is that involving the dynamics of interconnected masses. Included in this class are problems of linear and torsional vibration, critical speeds of loaded shafts, vibration isolation, impact, automatic control, and others. When the masses involved are all rigid and the interconnecting elastic members have negligible inertia, or at least have been reduced effectively to zero inertia by applying appropriate corrections to the end masses, the differential equations governing the motions of these masses are usually second-order ordinary differential equations based on Newton's laws of motion. There are as many equations to be solved simultaneously as there are masses in the system.

Problems involving the vibration of continuous members, such as shafts, beams, plates, and the like, actually are governed by the wave equation, a partial differential equation falling into the category of the first section on "engineering problems." However, the most usual engineering practice is to subdivide such continuous members into an equivalent set of rigid masses interconnected by massless springs. Under such circumstances the ordinary differential equations will apply. This procedure is particularly useful when the continuous member has a variable or stepped cross section, or carries concentrated masses.

The simplest case which one might consider is the mass (m) suspended on a spring (k) and subjected to a sinusoidal force (F_0) of frequency ω. A dashpot (c) across the spring provides damping. For this system Newton's laws of motion give the equation

$$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = F_0 \sin \omega t \qquad [28]$$

or, in terms of velocity instead of displacement

$$m\frac{dv}{dt} + cv + k\int v\,dt = F_0 \sin \omega t \qquad [29]$$

In a lumped-series electric circuit, consisting of an inductance L, a resistance R, a capacitance C, and a sinusoidal voltage source E_0, Kirchhoff's law for the voltage sum around the circuit gives the equation

$$L\frac{di}{dt} + Ri + \frac{1}{C}\int i\,dt = E_0 \sin \omega t \qquad [30]$$

In an electric circuit in which these elements are arranged in parallel, Kirchhoff's law for the current sum at a node gives the equation

$$C\frac{dE}{dt} + \frac{1}{R}E + \frac{1}{L}\int E\,dt = I_0 \sin \omega t \qquad [31]$$

Obviously Equations [29], [30], and [31] are analogous, so that either electrical system may be used for studying the behavior of the mechanical system. In the series electric circuit, inductance, resistance, and reciprocal capacitance are

analogous, respectively, to mass, damping coefficient, and spring stiffness (22). This is generally referred to as the mass-inductance analogy. Voltage drop and current are analogous, respectively, to force and velocity.

In the parallel electrical circuit, capacitance, reciprocal resistance, and reciprocal inductance are analogous, respectively, to mass, damping coefficient, and spring stiffness (23, 24). This is generally referred to as the mass-capacitance analogy. Current and voltage drop are analogous, respectively, to force and velocity.

In general, the mass-inductance analogy is preferred in experimental work because fewer complications are involved in generating constant-amplitude voltages for exciting the circuit.

In its application to machine-design problems, the electrical analogy finds its special place in solving problems in the vibration of extended systems having many degrees of freedom, whether the vibration problem be concerned with linear vibration, torsional vibration, beam vibration, or critical speeds. The procedure in setting up a mass-inductance analogy for an extended system is straightforward. The guiding thought in the procedure is that a voltage source distributes itself among the series-circuit elements connected across it in the same manner as a force distributes itself among the mechanical elements on which it acts.

Thus, for example, in the simple case just considered, the external force applied to the mass at any instant is divided between the following functions: (*a*) it accelerates the mass; (*b*) it overcomes the dashpot resistance; (*c*) it overcomes the spring reaction. Similarly, the voltage generated by the voltage source is divided among the following voltage drops: (*a*) The drop across the inductance; (*b*) the drop across the resistance; (*c*) the drop across the capacitance.

In extended systems the nth mass is connected to the preceding $(n-1)$th mass through the $(n-1)$th spring and, if damping is present, through the $(n-1)$th dashpot, also. Consequently, whatever force reaches the nth mass to accelerate it must come from the $(n-1)$th spring and dashpot. If there is yet another spring and dashpot (the nth) beyond this mass, then some of the force from the $(n-1)$th spring and dashpot must be diverted to overcoming the nth spring and dashpot, so that possibly only a portion of it is used in accelerating the nth mass at the given instant. In an electrical circuit this means that the voltage across the $(n-1)$th series resistance and capacitance must be impressed across the nth inductance for the case of an end mass alone, or, in the event of an nth spring-dashpot combination, the voltage across the $(n-1)$th series resistance and capacitance must be impressed across a series circuit consisting of the nth inductance, resistance, and capacitance. If an $(n+1)$th mass is present at the end of the nth spring-dashpot, then an $(n+1)$th inductance must be added to the electrical analog in such a manner that the voltage across the nth resistance-capacitance combination is impressed across the $(n+1)$th inductance. With added springs, dashpots, and masses, the process repeats itself so that eventually an electrical network is built up which has as many loops in it as there are masses in the mechanical system.

In vibration problems there are usually two matters of primary interest, namely, (*a*) the resonant frequencies (or critical speeds) of the system, and (*b*) the vibration loads on the connecting shafting (or springs) in the system at or near the resonant frequencies falling in the operating range. These values are measured readily in the laboratory on an electrical model even for the most complex systems, whereas a numerical analysis with the aid of desk calculators may be prohibitively time-consuming. The harmonic-force components may be introduced simultaneously by sinusoidal voltage sources properly phased and of appropriate amplitudes to represent the actual complex periodic force acting on the system. Measurements of voltage variation across the different capacitors in the electrical system are proportional to the load variation in the corresponding springs.

The electrical-analogy method has been discussed by Concordia (25) with respect to the analysis of torsional oscillations of ship drives. The mass-capacitance analogy was used by Stewart (26) in an experimental study of crankshaft vibration of Allison in-line engines. Natural frequencies and relative vibration amplitudes for the engine system were determined readily, with good agreement between engine results and model tests.

The response of complicated elastically interconnected systems to impact also is determined with relative ease by means of an electrical analogy. In the mass-inductance analogy a voltage pulse, corresponding in intensity and duration to the force impulse during impact, provides the necessary excitation to the electrical circuit. Criner, McCann, and Warren (27) illustrate the use of the analogy for studying the ridability of an automobile striking a stepped surface in the road. In another article (28), McCann and Kopper present electrical analogs for the study of the behavior of falling systems striking a floor, e.g., electronic-tube package drops.

A general-purpose large-scale computing machine (29) based on analog principles, discussed in this paper, has been developed jointly by the Westinghouse Electric Corporation and the California Institute of Technology. Called the "Anacom," the computer is installed in the Westinghouse computing laboratories. A similar unit is installed at the California Institute of Technology. Consisting of great numbers of electrical-circuit elements and accessory equipment, these computers are capable of handling a wide range of problems in the mechanical and electrical fields. Speaking of the mechanical-transients analyzer, McCann and Criner state:[3] "In the first six months that the mechanical-transients analyzer has been in use, the number of problems solved that could have been done by conventional mathematical analysis would have required two mathematicians working for a period of at least fifteen years. In addition, several important problems have been analyzed that could not be done at all by conventional mathematics."

THE DIFFERENTIAL ANALYZER IN DESIGN ANALYSIS

The analogs developed in the preceding sections were designed to simulate the behavior of certain physical systems. As a result, the scope of application of the analog is restricted to a relatively narrow class of phenomena. For example, the lumped-circuit analogs developed for vibration and impact problems are suited only to systems which are governed by the second-order differential equation, Equation [28], or by sets of simultaneous equations of this type.

The differential analyzer, on the other hand, is an analog-computing device designed to solve ordinary differential equations virtually of any complexity within the capacity of the machine. It is not restricted to second-order differential equations or to systems of second-order equations, but will solve equations of any order up to the limit of the number of integrators incorporated in it.

Differential analyzers of two types are prominent in literature. The mechanical differential analyzer (30, 31), developed by the Massachusetts Institute of Technology over the past twenty years to a high state of precision and versatility, and the electronic differential analyzer (32), developed in recent years by the Reeves Instrument Corporation, New York, N. Y.

Some idea of the capacities of present-day mechanical differential analyzers may be obtained from the fact that the Massachusetts Institute of Technology's differential analyzer has 18

[3] Bibliography (29), p. 31.

integrators with a projected capacity of 30, and a similar differential analyzer at the University of California, Los Angeles, has 14 integrators. In general, the number of integrators is usually the factor limiting the capacity of the machine. As many integrators are necessary as the combined order of all the differential equations to be solved simultaneously on this machine. In addition, integrators are frequently used to generate functions or to multiply variables together, although plotted functions may be fed into the system by means of input tables (either manually or photoelectrically controlled), and multiplication may be done with special units designed for this purpose.

In the mechanical differential analyzer the values of variables or of combinations of variables as they occur in the equation are given by rotations of shafts. For this reason the differential analyzer contains a maze of stub shafts which may be interconnected with spur gears (for multiplying by a constant), with differential gears (for adding) and with right-angle gearboxes (for connecting shafts crossing at right angles). The integrators are essentially planimeters in which the wheel (the integral) is turned by a rotating disk (the differential variable) on which it rests. A lead screw (the integrand) varies the position of the wheel with respect to the disk center.

The differential analyzer is capable of solving many types of nonlinear differential equations. Nonlinear functions are easily introduced through input tables. Also, the mechanical unit may be stopped at any time and discontinuities introduced by shifting the integrating wheel manually from one position to another and then restarting the machine to continue the solution.

Accurate workmanship and error-correcting devices combine to make the mechanical differential analyzer the most precise analog computer in existence.

In the REAC (Reeves Electronic Analog Computer) the values of the variables are represented by voltages. Summing amplifiers, integrating amplifiers, and potentiometers provide for the processes of adding, integrating, and multiplying. Multiplication by fixed constants, namely, 1, 4, and 10, is accomplished in the summers and integrators. Other values are obtained by using the scale-factor potentiometers in combination with these units.

Containing seven integrating amplifiers in the commercial unit (model C101) the device is capable of solving ordinary differential equations totaling to the seventh order. Used in multiples, differential equations of correspondingly higher order can be treated. Servounits are used to introduce nonlinear functions.

ALGEBRAIC-EQUATION SOLVERS

It would not be amiss to mention some other devices which remove the drudgery involved in obtaining the roots of high-order algebraic equations. Such equations result, for example, in the analysis of vibrating systems with several degrees of freedom.

Berry, Wilcox, Rock, and Washburn (33) describe a 12-equation commercial computer of the Consolidated Engineering Corporation. A network of resistors and potentiometers is used to perform multiplications of number pairs, and additions and subtractions of resulting products. The method of solution consists of introducing an approximate or guessed solution as a first approximation, from which a second approximation is obtained, then a third, and so on until a steady solution is derived. This is done by adjusting the potentiometers successively until no further changes are necessary to null the panel indicator in switching to any equation.

An electrical algebraic-equation solver (34, 35), developed at the University of Pennsylvania, determines all the roots of an algebraic equation of eighth degree having real coefficients Nine alternating-current generators have rotors mounted on a common shaft driven by a motor. The stators of 8 generators may be rotated manually and are coupled through gears so that prescribed relative rotations occur in accordance with the solving process. The output terminals of the generators are connected to two sets of potentiometers, one set being adjusted to the values of the coefficients in the equation, and the other set having its contactors coupled together so as to have prescribed relative motions in accordance with the solving process. By varying the stator and the potentiometer positions successively until the potential drop across a series circuit composed of the movable potentiometers becomes zero, the final settings of stators and potentiometers give the roots of the equation.

A completely mechanical root-finder using slider-crank mechanisms and pulleys was developed by the Bell Laboratories Called the "Isograph" (36, 37), this machine accomplishes essentially the same results as the University of Pennsylvania machine. The time required for solving an eighth-degree polynomial with complex roots was reduced from 4 days by previous methods to 1 day with its use.

[Since this paper was released, the author has found in literature two excellent applications of the soap-film analogy to a determination of the isopachic lines in photoelastic stress problems and an application of the analogy to potential and field strength measurements about electrodes (38, 39, 40).—EDITOR.]

BIBLIOGRAPHY

1 "Theory of Elasticity," by S. Timoshenko, McGraw-Hill Book Company, Inc., New York, N. Y., 1934, chapt. 9.

2 "Torsional Stress Concentrations in Shafts of Circular Cross Section and Variable Diameter," by L. S. Jacobsen, Trans. ASME, vol. 47, 1925, p. 619.

3 "Calculation of Stresses Within the Boundary of Photoelastic Models," by R. Weller and G. H. Shortley, *Journal of Applied Mechanics*, Trans. ASME, vol. 61, 1939, p. A-71.

4 "The Mechanics of Porous Flow Applied to Water-Flooding Problems," by R. D. Wyckoff, H. G. Botset, and M. Muskat, Trans AIME, Petroleum Division, vol. 103, 1933, p. 219.

5 "Predicting Wet Gas Recovery in Recycling Operations," by J. S. Swearingen, *The Oil Weekly*, vol. 96, Dec. 25, 1939, p. 30.

6 "Studies in Lubrication. VI. Electrolytic Models of Full Journal Bearings," by F. Morgan, M. Muskat, and D. W. Reed, *Journal of Applied Physics*, vol. 11, 1940, p. 141.

7 "The Use of Soap Films in Solving Torsion Problems," by A. A. Griffith and G. I. Taylor, Advisory Committee for Aeronautics (British). R. and M. 333, 1917-1918.

"The Application of Soap Films to the Determination of the Torsion and Flexure of Hollow Shafts," by A. A. Griffith and G. I. Taylor, Advisory Committee for Aeronautics (British), R. and M. 392, 1917-1918.

8 "An Electrical Geometrical Analogue for Complex Heat Flow," by C. F. Kayan, Trans. ASME, vol. 67, 1945, p. 713.

9 "Conformal Transformation With the Aid of an Electrical Tank," by K. N. E. Bradfield, S. G. Hooker, and R. V. Southwell, Proceedings of the Royal Society of London, series A, vol. 159, 1937, p. 315.

10 "Flow of Heat Through Furnace Walls: The Shape Factor," by I. Langmuir, E. Q. Adams, and G. S. Meikle, Trans. American Electrochemical Society, vol. 24, 1913, p. 53.

11 "An Electrical Method of Tracing Stream Lines for the Two-Dimensional Motion of a Perfect Fluid," by E. F. Relf, Advisory Committee for Aeronautics (British), R. and M. 905, 1924.

12 "The Use of Rheo-Electrical Analogies in Certain Aerodynamical Problems," by L. Malavard, *Journal of the Royal Aeronautical Society*, vol. 51, 1947, p. 739.

13 "The Electrolytic Model and Its Application to the Study of Recovery Problems," by H. G. Botset, Trans. AIME, Petroleum Division, vol. 165, 1946, p. 15.

14 "A Mechanical Method for Solving Problems of Flow in Compressible Fluids," by G. I. Taylor and C. F. Sharman, Proceedings of the Royal Society of London, series A, vol. 121, 1928, p. 194.

15 "On Problems in the Theory of Fluid-Film Lubrication, With an Experimental Method of Solution," by A. Kingsbury, Trans. ASME, vol. 53, paper no. APM-53-5, 1931, p. 59.

16 "Effects of Side Leakage in 120-Degree Centrally Supported Journal Bearings," by S. J. Needs, Trans. ASME, vol. 56, 1934, p. 721.

17 "Die Angenaherte Ermittelung Harmonischer Funktionen und Konformer Abbildungen," by H. Liebmann; *Sitzungberichte, der Bayerischen Akademie der Wissenschaften zu München, Mathematische Physikalische Klasse*, 1918, p. 385.
18 "The Numerical Solution of Laplace's Equation," by G. H. Shortley and R. Weller, *Journal of Applied Physics*, vol. 9, 1938, p. 334.
19 "A Method for Determining Unsteady-State Heat Transfer by Means of an Electrical Analogy," by V. Paschkis and H. D. Baker, Trans. ASME, vol. 64, 1942, p. 105.
20 "An Electrical Device for Analyzing Oil Reservoir Behavior," by W. A. Bruce, Trans. AIME, Petroleum Division, vol. 151, 1943, p. 112.
21 "Electric Method for the Solution of Laplace's Equation," by V. Paschkis, Proceedings of the Society for Experimental Stress Analysis, vol. 2, 1944, p. 39.
22 "Oscillographic Solution of Electromechanical Systems," by C. A. Nickle, Trans. AIEE, vol. 44, 1925, p. 844.
23 "A New Analogy Between Mechanical and Electrical Systems," by F. A. Firestone, *Journal, ASA*, vol. 4, 1932-1933, p. 249.
24 "The Mobility Method of Computing the Vibration of Linear Mechanical and Acoustical Systems: Mechanical-Electrical Analogies," by F. A. Firestone, *Journal of Applied Physics*, vol. 9, 1938, p. 373.
25 "Network Analyzer Determination of Torsional Oscillations of Ship Drives," by C. Concordia, Trans. The Society of Naval Architects and Marine Engineers, vol. 51, 1943, p. 51.
26 "Electrical Model for Investigation of Crankshaft Torsional Vibrations in In-Line Engines," by H. B. Stewart, SAE Transactions, vol. 54, 1946, p. 238.
27 "A New Device for the Solution of Transient-Vibration Problems by the Method of Electrical-Mechanical Analogy," by H. E. Criner, G. D. McCann, and C. E. Warren, *Journal of Applied Mechanics*, Trans. ASME, vol. 67, 1945, p. A-135.
28 "Generalized Vibration Analysis by Means of the Mechanical Transients Analyzer," by G. D. McCann and J. M. Kopper, *Journal of Applied Mechanics*, Trans. ASME, vol. 69, 1947, p. A-127.
29 "Mechanical Problems Solved Electrically," by G. D. McCann and H. E. Criner, *Westinghouse Engineer*, vol. 6, 1946, p. 48.
30 "The Differential Analyzer. A New Machine for Solving Differential Equations," by V. Bush, *Journal of The Franklin Institute*, vol. 212, 1931, p. 447.
31 "A New Type of Differential Analyzer," by V. Bush and S. H. Caldwell, *Journal of The Franklin Institute*, vol. 240, 1945, p. 255.
32 "Compact Analog Computer," by S. Frost, *Electronics*, vol. 21, July, 1948, p. 116.
33 "A Computer for Solving Linear Simultaneous Equations," by C. E. Berry, D. E. Wilcox, S. M. Rock, and H. W. Washburn, *Journal of Applied Physics*, vol. 17, 1946, p. 262.
34 "Mechanical Solution of Algebraic Equations," by H. C. Hart and I. Travis, *Journal of The Franklin Institute*, vol. 225, 1938, p. 65.
35 "An Electrical Algebraic Equation Solver," by D. L. Herr and R. S. Graham, *Review Scientific Instruments*, vol. 9, 1938, p. 310.
36 "The Isograph—A Mechanical Root Finder," by R. L. Dietzold, *Bell Laboratories Record*, vol. 16, 1937-1938, p. 130.
37 "The Mechanism of the Isograph," by R. O. Mercner, *Bell Laboratories Record*, vol. 16, 1937-1938, p. 135.
38 "Studies in Photoelastic Stress Determination," by E. E. Weibel, Trans. ASME, vol. 56, 1934, paper no. APM-56-13, p. 637.
39 "A Membrane Analogy Supplementing Photoelasticity," by J. G. McGivern and H. L. Supper, Trans. ASME, vol. 56, 1934, paper no. APM-56-9, p. 601. (Also in *Journal of The Franklin Institute*, vol. 217, 1934, p. 491.)
40 "The Stretched Rubber Sheet", by J. H. Fremlin and J. Walker, *Journal of Scientific Instruments*, vol. 24, 1947, p. 50.

Human Factors in Design of Manual Machine Controls

(*Continued from page 816*)

3 For small frictional torques, 0 and 20 in-lb, the 36-in. and 48-in. heights give optimum operating results with cranks. For large frictional torques, the 40-in. height with —45-deg axis gives optimum results with handwheels. Comparable results at the large torques are obtained with cranks at the 48-in., 36-in., and 40-in., —45-deg axis locations.

4 The comparison as to performance between cranks and handwheels at the various locations is as follows:

(*a*) Better performance is achieved with cranks than with handwheels at the 36-in. and 48-in. heights, horizontal axis.

(*b*) Comparable performances are given with both cranks and handwheels at the 39-in. height, vertical axis, 58-in. height, horizontal axis, and 40-in. height, —45-deg axis.

(*c*) Cranks give better performance at the higher torques for the 42-in., +45-deg axis. For the other torques, a comparable performance is provided with both cranks and handwheels at this location.

5 The designer may wish to know what control shaft torques to incorporate in his design for optimum operating conditions. This information is of value if certain sized control devices have become customary for a specific product or location.

(*a*) For the small control devices, such as 3 in. and 6 in-diam wheels and $1^1/_2$ in., $2^1/_2$ in., and $3^1/_2$ in-radius cranks, optimum operation is obtained in the minimum frictional torque, at all locations.

(*b*) For the large control devices, 8 in., 10 in., and 15 in-diam wheels and $4^1/_2$ in. and $7^1/_2$ in. radius cranks, optimum operation is obtained at the divergence points, i.e., 20 in-lb to 40 in-lb of frictional torque for all locations.

These findings are based upon accomplishing the setting of the control device in 1 revolution. For settings requiring less than 1 revolution, particularly those requiring a turn of 90 deg or less, it can be inferred from experience that handwheels probably would be more effective than cranks. In these cases the operator probably would turn the handwheels, using the rim rather than the handle on the wheel. Future studies are to be undertaken involving partial revolutions of the various control mechanisms, and involving types of movements and motion patterns required to operate various control devices at different locations.

BIBLIOGRAPHY

1 "Psychological Research on Equipment Design," Report No. 19, Army Air Forces, Aviation Psychology Research Reports, edited by Paul M. Fitts, U. S. Government Printing Office, 1947.
2 "Factors Determining Accuracy of Tracking by Means of Handwheel Control," Foxboro Company, to Div. 7 NDRC, OSRD Reports 3451, 3452, 3453, 3454, 3455.
3 "Ideal Torques for Handwheels and Knobs," by A. Raines and J. H. Rosenbloom, *Machine Design*, vol. 18, August, 1946, pp. 145-148.
4 "Are Your Controls Properly Designed, Effectively Placed?" by Harold Sizer, *Machine Design*, vol. 16, November, 1944, pp. 111-115.
5 "Human Factors in Air Transport Design," by Ross A. McFarland, McGraw-Hill Book Company, Inc., New York, N. Y., 1946.
6 "Factors Affecting Handwheel Design," by W. E. Hick, APU 26, Medical Research Council, Great Britain.
7 "The Effect of Heavy Loads on Handwheel Tracking," by W. E. Hick, APU 47, Medical Research Council, Great Britain.

IN EXPERIMENTS using radioactive "tracers," atoms "tagged" with radioactivity so their movements can be traced, engineers of the G-E General Engineering and Consulting Laboratory have devised a method revealing photographically how rust starts, where it starts, and how deep it goes.

C. G. Bacon, development engineer, explained that radioactive tracers are ideal in rust experiments because radioactivity is not affected by chemical change. Rust, he pointed out, is the result of a change in which iron and oxygen combine.

In experiments using radioactive isotopes obtained from Oak Ridge, Tenn., a solution holding radioactive iron is electroplated onto the surface of the metal to be studied. Then a photographic plate is placed against this surface and left for several days. During this time, an x-ray exposure is made on the plate by the radioactive coating. As the test metal rusts, a decrease in radiation results, showing up graphically as lighter areas on the photographic plate. By taking a series of these "pictures," called autoradiographs, the engineers can see photographically the nature of the rust forming on the test metal.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

COMPILED AND EDITED BY J. J. JAKLITSCH, JR.

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Invention and Incentive

INVENTION, with a view to increasing the number and value of inventions, was discussed by E. G. Bailey, past-president and Fellow ASME, in the 1949 James Clayton Lecture which he presented before a meeting of The Institution of Mechanical Engineers in London, England. Besides explaining the relation between research and invention, the various incentives to invent, and the important steps in reducing an invention to practice, Mr. Bailey gave some illustrations from his own experience in developing steam combustion and steam-generation equipment to show how simple the process of invention is when there is an incentive.

Mr. Bailey obtained firsthand experience in the firing of slabs, sawdust, shavings, corncobs, and coal in his father's sawmill in Ohio during the 1890's. Following this, he gained valuable experience in firing about 100 boiler tests, burning several different kinds of coal, at the Ohio State University, 1900–1903.

During the following seven years (1903–1910) his work provided the opportunity to take part in and observe the operation and testing of stationary, marine, and locomotive boilers, as well as a variety of furnaces in copper smelters, steel plants, cement plants, gas producers, and other coal-burning equipment. The fuel was mostly bituminous coal, hand-fired, with some stoker-fired boilers and pulverized coal in cement plants. Some natural gas was encountered in the firing of glass and boiler furnaces. Few firemen had any instruments to guide them in their work, but all were eager to learn about combustion efficiency through the use of draft gages and the Orsat gas-analyzing apparatus, which were carried as portable test equipment.

To meet the need for some permanent combustion guide, Mr. Bailey started to develop an automatic continuous gas analyzer, but before completing it, carbon-dioxide recorders became available. The early experience with these recorders left much to be desired; largely because the one component, carbon dioxide, of the gas analysis was inadequate for the needs of the fireman.

It was necessary to understand the problems involved in hand-firing coal and appreciate the difficulties confronting the fireman, to decide what information he needed in order to obtain best results. The fuel-bed condition controls the combustion efficiency, and should be maintained uniformly level and of the correct thickness.

Furnace Indicator. During the firing of the boiler tests at Ohio State University it was observed that the Ellison draft gage connected to the furnace responded to the condition of the fuel on the grate. This draft reading was not only responsive to the resistance to the flow of air through the fuel bed, but also to the rate of output. After more than a year's study the problem of using draft readings to operate a reliable combustion guide was on its way toward a solution.

The resulting furnace indicator was based upon the principle of the Wheatstone bridge used for measuring electrical resistance, but it employed the draft differentials to determine the fuel-bed condition by measuring the resistance of the bed to the flow of air. The grate bars used at that time had about 50 per cent air space and gave little resistance to air flow as compared with the fuel bed.

The furnace indicator, useful as it was for its original purpose of recording the fuel-bed condition, did not measure the quantity of steam produced, which from the fireman's point of view was far more important than to keep the recorder pen within the shaded band of the chart. It was desirable for the recorder to give the entire story of boiler operation. After many months of development and trial installations, a steam flowmeter was developed for use with Pitot tubes. Later the orifice was explored and developed and subsequently the use of a combined bell and displacer was adopted.

The steam flow as a measure of output was valuable, but alone gave no indication of combustion efficiency. As furnaces became larger and the multiple-retort underfeed stoker became temporarily popular, the furnace indicator was less helpful, because the high resistance of the stoker grates, with small air space, diminished the relative effect of the fuel bed itself. The furnace indicator was doomed to be discarded, but the differential draft loss across the boiler passes had become recognized as a valuable indication, because it varied closely with the boiler output.

By that time it was recognized that a combustion guide could be made by comparing the air-flow reading with that of the steam flow. It would of course be necessary to design the

How to Obtain Further Information on "Briefing the Record" Items

MATERIAL for this section is abstracted from: (1) technical magazines; (2) news stories and releases of manufacturers, Government agencies, and other Institutions; and (3) ASME technical papers not preprinted for meetings. Abstracts of ASME preprints will be found in the "ASME Technical Digest" section.

For the texts from which the abstracts of the "Briefing the Record" section are prepared, the reader is referred to the original sources, i.e.: (1) The technical magazine mentioned in the abstract, which is on file in the Engineering Societies Library, 29 West 39th St., New York 18, N. Y., and other libraries. (2) The manufacturer, Government agency, or other institution referred to in the abstract. (3) The Engineering Societies Library for ASME papers not preprinted for meetings. Only the original manuscripts of these papers are available. Photostat copies may be purchased from the Library at usual rates, 40 cents per page.

air-flow mechanism so that it could be adjusted to read the same as the steam flow when the most economical combustion conditions existed. The combustion reaction may be calculated in terms of Btu per lb of air as well as in terms of the usual calorific value of the fuel. For example, combining one pound of air with the normal commercial fuels, such as different kinds of coal or oil, will develop substantially the same heat.

With the Bailey boiler meters currently in use, the air flow is adjusted so that the steam-flow and air-flow pens read the same, i.e., a ratio of 1.0, when the correct combustion conditions exist, regardless of the rate of steam output. The meter can be calibrated and standardized by making a series of combustion tests and adjusting the air flow for each individual boiler and fuel, so as to properly guide the fireman in burning coal whether in a fuel bed or in pulverized form. It can also be adapted to the firing of oil, gas, or other fuels.

Recently developed oxygen recorders are becoming recognized as valuable guides for all conditions where combustion of fuel takes place. They are often installed in addition to the steam-flow and air-flow or the fuel-flow and air-flow recorders as continuous checks, to aid in starting up, and to meet unusual operating conditions.

It is difficult to see how the steam and the air flowmeter could have been invented, if it had not been preceded by the furnace indicator.

Automatic Combustion-Control. It is obvious that if a meter serves as a reliable operating guide for a fireman, it should be incorporated into an automatic control system whereby the fireman need be only a supervisory operator, without the necessity for continuous attention to the many details of the fuel and air supplies.

After pulverized coal came into more extended use, larger boilers were possible; the means for supplying air and fuel to the furnace became more complicated, and the need for automatic control became essential. For instance, in an installation made in 1923, the boiler steam pressure falls or rises as the load is increased or decreased; a change in steam pressure causes the air and fuel supply to be changed to restore the pressure to normal by meeting exactly the changes in load demand. The steam and air flowmeter is continually active in adjusting the air supply to match the rate of fuel supply for the most economical combustion conditions.

In another modern plant the mechanical functions are performed by air-operated control drives which are guided by the instruments of a system of communication.

The development of this control equipment did not require invention of the same degree as was needed for the early steps in the development of the boiler meter, because by that time the relationships between the different factors were known, and it was largely a problem of harnessing them to the instruments. There was need for many secondary inventions by many individuals in order to adapt the instruments through intermediate mechanisms to the heavy motor- or piston-operated dampers, without interfering with the accuracy of the meter reading and chart records.

The development and use of the three-element feedwater control was deferred several years after the fundamental requirements were fully known. This delay was intentional, in order to verify the accuracy and reliability of the flowmeter and level recorder type of mechanism before depending upon them for that important control function.

Pulverized-Coal Feeder. The problem of feeding pulverized coal from bin systems seemed important enough to analyze and solve. This resulted in the development of the pulverized-coal feeder. This was useful in overcoming several shortcomings of other equipment; the opening in the bin was large enough to prevent the damp coal from bridging; the undercutting distributor kept the coal free to enter the fluffer wheel; the fluffer wheel received coal of varying density according to the depth and packing in the overhead bin, and delivered it to the feeder wheel in a state of uniform density; and the feeder wheel filled each pocket full of coal of uniform density and remained isolated both from the bin and the delivery conditions. This feeder delivered pulverized coal at a satisfactorily uniform rate from the bins, regardless of whether the coal was dry or damp.

Water-Cooled Furnace. With the advent of the steam turbine, and the multiple-retort underfeed stoker, shortly after the turn of the century, superheated steam, higher pressures, and larger boiler units were needed. The trend toward increased height and size of boiler settings developed to the point where brick walls were taxed beyond any possible satisfactory endurance. Air-cooled refractory walls were also inadequate. Thus with the increased ratings and higher furnace temperatures resulting from better control of excess air, there developed a definite need for water-cooled furnaces.

Some of the first water-cooled furnace walls consisted of spaced bare tubes with refractory material between them, while others had bare tubes with welded-on fins designed to fill the spaces. The former construction was too hot and the latter too cold to obtain the best results in combustion efficiency under some conditions.

The problem was considered and several different types of construction were developed. These designs are fairly well known through their extended use over the past 25 years.

At first waterwalls were designed as a substitute for part of the brick walls of the furnace, and were as independent of the standard boilers as possible. It was not long before the boiler and furnace were combined as one unit, with more consideration being given to the fuel supply, burners, and ash and slag problems, than to heat absorption alone.

The burning of coal for the generation of power and other applications of heat is among the most important bulwarks of civilization. All progress of the past has brought us to its use at present by four different methods—hand-firing, stokers, gasification, and pulverized fuel.

An analysis of the detailed experience with all types of coal-burning equipment led to the invention of the cyclone furnace.

With this method of combustion, the coal is crushed to $^1/_4$ in. and smaller, then introduced with primary air into a cylindrical furnace where combustion is practically completed by hot secondary air, which is injected into the furnace tangentially at a high velocity. The furnace is so hot that all of the ash is in a molten liquid state when liberated from the burning coal, and forms a wet film over practically the entire inner surface of the furnace. The particles of coal actually are caught on this liquid slag film, somewhat as flies are caught on sticky paper, and are burned there at a very high rate. A large percentage of the ash is continuously tapped from the cyclone furnace as molten slag, chilled and disintegrated by water jets, and removed from the slag pit.

This method of burning coal results in no smoke and less pollution of the atmosphere from grits in chimney gases, than from other methods of combustion, and with a minimum of collecting equipment.

This is a brief history of some of the inventions within one branch of engineering. There is still opportunity for further work and inventions in the field of power generation from coal.

The present trends and future needs for invention in different fields were also discussed by Mr. Bailey under the headings of products and processes, communications, transportation, and power and heat.

The complete Clayton Lecture with illustrations appears in the Proceedings of The Institution of Mechanical Engineers, vol. 160, No. 2, 1949 (September). A limited number of re-

prints of the article are available from the author, E. G. Bailey, vice-president, Babcock and Wilcox Company, 85 Liberty Street, New York 6, N. Y.

Jet-Propelled Airliner

THE de Havilland Comet (DH 106) jet-propelled airliner, an aircraft which will probably become a milestone in commercial-aviation history, flew for the first time on July 27, according to *Engineering*, Aug. 5, 1949. It is powered by four de Havilland Ghost gas-turbine engines, each delivering 5000 lb static thrust.

The de Havilland Comet is designed as a high-speed airliner for operation over trunk routes, carrying up to 36 passengers. Economical operation of the Ghost turbojets requires the aircraft to fly at high altitudes, and the Comet has been designed for a cruising altitude of 40,000 ft, at which the estimated cruising speed is about 500 mph true air speed. For these high altitudes, a cabin pressure differential of 8 psi is to be used, which is considerably higher than has been used hitherto on commercial airplanes. The cabin air conditioning also provides for temperature and humidity control. The general appearance of the Comet is conventional; the wings have only moderate sweepback; leading-edge shots are fitted on the outer wing. The four Ghost engines are closely grouped, this arrangement giving excellent control characteristics under asymmetrical power conditions. The cabin air intakes are located under the inboard engines. The main undercarriage legs retract outward and the nosewheel retracts backward; the large main undercarriage wheels are temporary features, to be replaced in later aircraft by bogies. This will allow the smoothing-out of a slight bulge in the wing, which is at present necessary for housing the main wheels.

The orthodox layout of the Comet has been adopted, together with a moderate wing loading, so that the take-off, let-down, approach, and landing characteristics will be similar to those of present-day transport aircraft, and the Comet will therefore be able to operate from any normal main-line airport.

The engine installation has resulted in a lower structure weight, not only because the turbojet engines are lighter than either piston engines or propeller-turbine power plants of equivalent power, but also because it has been possible to keep the undercarriage units short, there being no propeller-clearance problem to consider. An interesting feature of the structural design is that Redux metal-to-metal bonding has been used extensively, considerably reducing the amount of riveting. Where it has been necessary to employ rivets on the exterior surfaces of the aircraft, flush riveting has been used.

The Ghost engines are nearly enclosed in the wing, which is of relatively thin section; this gives much lower drag, as compared with an equivalent piston-engine installation. Since the Comet is opening up a new phase in commercial flying, the constructors are devoting a considerable period to test flying and to operational development flights. It is expected that the Comet will be flying over British trunk routes in 1952-1953.

Gold Plating

KARAT gold can now be rolled to a mirror finish and as thin as electroplate on any nonferrous metal base through the development of the Inter-Weld Process by the American Silver Company, Inc., Flushing, N. Y.

In ordinary gold electroplate the gold layer is usually less than 5/1,000,000 in. thick, soft and spongy, being deposited on the base metal by electric attraction, whereas in rolled-gold plate, the repeated processes of heat and tremendous rolling pressures produce a dense, tough, and durable layer of alloyed karat gold of any desired thickness. Improving on the so-called "Old Sheffield Process" wherein a layer of karat gold is silver-soldered to a base metal, the Inter-Weld Process welds the gold layer to a barrier layer of pure nickel and this dual thickness is then soldered to the base metal in the conventional manner. In the past it has been found impossible to manufacture mechanically plated karat gold rolled down to thicknesses approaching gold electroplate because of the tendency of the silver solder used as a bonding agent to diffuse or "bleed" through to the surface of the gold and present a mottled streaked appearance. By welding the gold layer instead of soldering it, and by the introduction of the barrier layer of nickel, this bleeding is overcome completely, see Fig. 2. Ratios as low as 1 to 600 have been achieved with a karat-gold thickness of 9/1,000,000 in. and less, with a brilliant mirror finish and no sign of bleeding.

The interposition of the nickel barrier and the use of welding instead of silver solder is said to represent the first major advance in mechanical plating of precious metals since 1742, when Bolsover, a silversmith of Sheffield, England, first developed the Old Sheffield Process. This new method permits control of the color of the gold which is uniform regardless of the thickness of the gold. One or both sides of a sheet may be plated to the same or different specifications of texture, color, and thickness. Inter-Weld rolled-gold plate is furnished in rolls, the coils interleaved with tissue or, if preferred, protected by a plastic-strip coating which may be left on during the stamping and drawing operations.

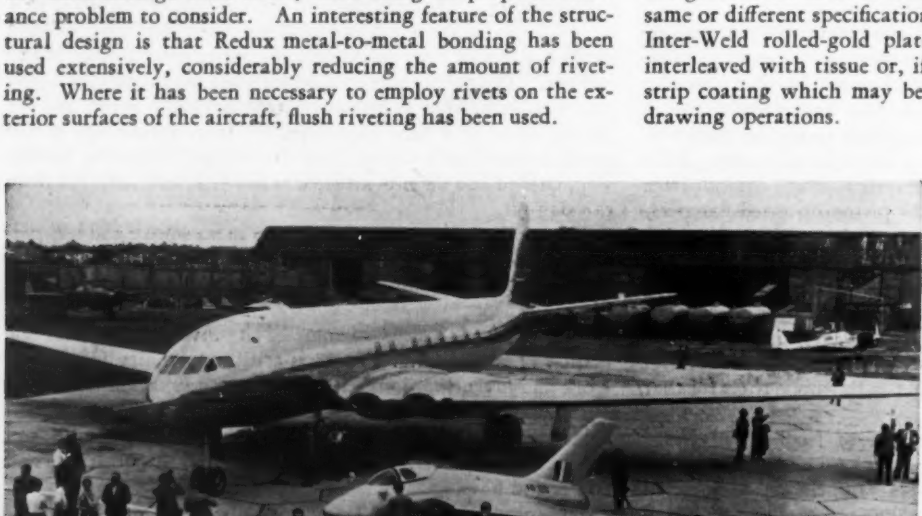


FIG. 1 VIEW OF NEW JET AIRLINER ON THE AIRFIELD AT HATFIELD, ENGLAND

(In the foreground may be seen the small jet DH 108, which was used to calculate wing resistance, stress, and strain for the new airliner.)

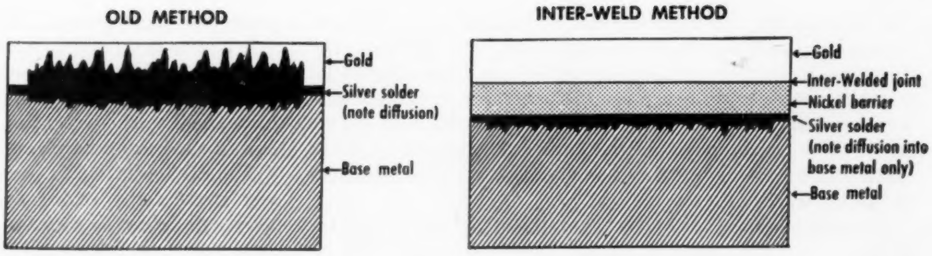


FIG. 2 OLD SHEFFIELD PROCESS (*left*) AND NEW INTER-WELD PROCESS (*right*)

Although this process was developed primarily for the manufacture of rolled-gold plate and gold filled, it is equally adaptable to the manufacture of silver items such as hollow ware, jewelry, and novelty articles now using silver electroplate. Inter-Weld gold-filled and rolled-gold plate is supplied on a base of brass, nickel silver, nickel, monel, cupronickel, or beryllium copper.

Shale-Oil Refinery

THE first continuous shale-oil refinery in this country, the new 200-barrel per day experimental unit near Rifle, Colo., has been put "on stream" without difficulty, the U. S. Bureau of Mines announced recently.

A highly flexible, continuous unit, the refinery is designed to produce gasoline, Diesel fuel, heating fuels, and fuel gas from crude shale oils extracted at the Bureau's Oil-Shale Demonstration Plant. It was built under contract with the Refinery Engineering Company of Tulsa, Okla., at a cost of $244,912.

Commercial utilization of the nation's gigantic oil-shale resources is a threefold problem, the announcement said, involving (1) mining the shale, (2) retorting the shale to produce oil, and (3) refining the shale oil into useful products. Operation of this new experimental unit under the Bureau's synthetic-fuels research and development program is expected to answer for private industry some of the technical and cost questions of shale-oil refining. The mining problem has been largely solved, for the Bureau's experimental oil-shale mine already has achieved low-cost production. Work on the retorting problem is well advanced, with research now concentrated on a pilot-plant retort designed for continuous operation.

As designed and built, the new experimental refinery is of the minimum size that will provide the desired information about shale-oil refining, including the operating characteristics and costs.

Major pieces of equipment include a furnace or heater, two cooking chambers, a combination flash vaporizer and fractionator, stripper for the Diesel-fuel fraction, stabilizer for the naphtha fraction, absorber, and a rerun column for acid-treated gasoline. With only minor changes, the same equipment can be used for atmospheric distillation, delayed coking, single-coil recycle cracking, or reforming. Facilities also are available for chemical treating of distillates.

In both function and design, the fractionation section is conventional. Heavy fuel residuum is withdrawn from the flash vaporizer at the base of the fractionating tower. Gas, oil, and Diesel fuel are taken off as sidestreams from the fractionator, and the Diesel fuel is stripped of its light components before being stored. The gasoline fraction is taken overhead as a vapor and condensed. Uncondensed gases go to the absorber where the condensable hydrocarbons are recovered and returned to the fractionator. Condensed gasoline is pumped to the stabilizer for removal of excessive quantities of butanes and lighter hydrocarbons, and the stabilized gasoline then is sent to the chemical treating unit.

In the treating unit, the distillate first receives a dilute caustic wash for the removal of hydrogen sulphide, light mercaptans, and tar acids. This is followed by a dilute sulphuric-acid wash for the removal of nitrogenous compounds, commonly called tar bases. Thus freed of its chemically active compounds, the distillate then is subjected to three stages of countercurrent extraction with concentrated sulphuric acid for sulphur removal, improvement of color, and oxidation stability. Next, it is washed with water and neutralized with a final dilute-caustic treatment. Following chemical treatment, the distillate is redistilled to remove the polymers formed in acid treating, and the specification end-point distillate is returned to the treating plant for "doctor" sweetening.

Radioisotope Distribution

CYCLOTRON-PRODUCED radioisotopes will be made available to research men under a program announced recently by the Atomic Energy Commission. With this additional supply of radioisotopes, which are produced in the accelerator type of atom-smashing machines, added to the varieties produced in the Oak Ridge reactor, research men will have a new collection of tools for finding answers to problems in general science, medicine, industry, and agriculture.

The cyclotron produces radioisotopes by bombarding material with electrically charged subatomic particles, which are accelerated to extremely high energies by successive electric impulses in a magnetic field. The nuclear reactor or pile produces radioisotopes by means of fission of uranium nuclei and by the bombardment of material by the resulting electrically uncharged subatomic particles, called neutrons.

The new program will augment the present distribution of reactor-produced radioisotopes which has been in effect since August, 1946. Approximately 7000 shipments of radioisotopes of nearly 60 elements representing nearly 100 isotopic species have been made for research purposes through the facilities of the Atomic Energy Commission.

Only those cyclotron-produced isotopes having half lives of more than 30 days will be distributed initially. Included in these valuable research tools are 43-day beryllium 7, 3-year sodium 22, 44-day iron 59, 4-year iron 55, 250-day zinc 65, 90-day arsenic 63, and 56-day iodine 125. Other cyclotron-produced radioisotopes of significant value as tools of research may be added at a later date.

Under the distribution arrangements, the Carbide and Carbon Chemicals Corporation, operator of the Oak Ridge National Laboratory for the Commission, will be authorized to purchase cyclotron time from various institutions operating such machines. Initial arrangements will be completed for cyclotron irradiations at the Massachusetts Institute of Technology, the University of Pittsburgh, Washington University at St. Louis, and the Crocker Radiation Laboratory at the University of California. The Department of Terrestrial Magnetism of the Carnegie Institution will render assistance to the general program.

In announcing the program, the Commission said that although the uranium chain-reacting reactor far surpasses the cyclotron in quantity production of radioisotopes created by fission and by certain other neutron reactions, a considerable number of important isotopes cannot be produced with the reactor. The cyclotron is a necessary and vital complement to the reactor for supplying tracer isotopes because of the wide variety of nuclear reactions it can produce.

Processing of irradiated targets will be carried out by the Oak Ridge National Laboratory in facilities already provided for handling reactor-produced isotopes. The Isotopes Division of the Commission will carry out the allocation function in the same manner as it now does with reactor-produced isotopes.

Cyclotron-produced radioisotopes, because of the method of their manufacture, are considerably more expensive than reactor-produced isotopes, and in order to price them at a level which will make them available to most research institutions, it will be necessary for the Commission to subsidize the program to a certain extent. In addition, these isotopes, like the reactor-produced radioisotopes now distributed by the Commission, will also be made available free of all production charges for cancer research.

The Commission said that cyclotron laboratories do not know and do not wish to undertake general sales of cyclotron-produced isotopes. Such laboratories are usually unable to handle the administrative tasks and voluminous correspondence involved in distribution, screening of formal requests, shipment problems, and legal arrangements connected with sale. Including distribution of cyclotron-produced isotopes into the present program for supplying reactor-produced radioactive isotopes will simplify maintenance of present policies on health-safety requirements, disposal procedures, and criteria for use in human beings. The distribution of materials produced under this program will be limited to institutions and organizations within the United States and its territories and possessions. Cyclotron-produced isotopes are more readily available abroad than reactor-produced isotopes because cyclotrons are in operation in many countries.

Deep-Diving Project

MORE than two thirds of the earth's surface is covered by oceans. If the water were suddenly removed, one would find mountains and valleys, vegetation and life much more abundant than is present on the solid surface of the earth. Thus far, our knowledge of the unobserved oceanic frontier consists mainly of surface observations, and random sampling of the ocean bottom with relatively inefficient collecting devices. The average depth of the ocean is almost three miles and parts of it are more than six miles deep. With the exception of a few dives made during 1930–1934, hardly any observations have been made below 300 feet.

In August, however, a series of experiments with a benthoscope were started to explore ocean depths much greater than previously. These experiments took place off the coast of Southern California and were conducted by Otis Barton, inventor of the benthoscope, and the Allan Hancock Foundation of the University of Southern California.

The benthoscope is a steel sphere, approximately five feet in diameter, large enough to hold two men, and strong enough to be lowered more than a mile into the ocean. It is so constructed that the scientists which it carries can observe what is in the ocean and what is on the bottom of the ocean. It is also equipped with large wheels, so that it can be pulled along the bottom of the ocean to study the many interesting things which live on the bottom or have fallen there after they have given up their struggle for existence in shallower water.

In air the benthoscope with two men aboard weighs approximately 7000 lb. In the water with two men aboard, it weighs approximately 3000 lb. In water the sphere is buoyed up by a force equal to the weight of the water displaced, which in the case of the benthoscope is 4000 lb.

The cable which has been obtained for the deep-sea diving test is especially strong and is composed of 136 steel wires woven together to make a steel cable $^5/_8$ in. in diam. It is constructed so that it will not rotate when it is stretched. At the conclusion of the manufacturing processes, this cable was tested with a 10,000-lb load, and portions of the cable have been tested to their ultimate breaking strength at the Allan Hancock Foundation laboratories in Santa Maria and have been found to hold about 30,000 lb before breaking.

The benthoscope is made of cast steel with two fused-quartz windows and neoprene-plastic seals. The entire sphere has been well-painted to prevent salt-water corrosion. The large wheels are made of wood and provide considerable surface so that the benthoscope will not sink into the ocean bottom. (These wheels were lost in an early test dive but they are soon to be replaced.)

The thinnest portion of the walls is $1^3/_4$ in. of cast steel. Many portions of the walls which are near openings or windows are much thicker in order to eliminate stress concentrations and possible cracking in sharp corners. It was designed to be usable to a maximum depth of over 10,000 ft.

The door through which the occupants must enter is 15 in. in diam. The window which looks straight ahead in the benthoscope is $5^3/_4$ in. in diam. This is large enough to accommodate the motion-picture camera, binoculars, and other optical equipment which will be used for making observations. The other window, which points toward the bottom, is $2^3/_4$ in.

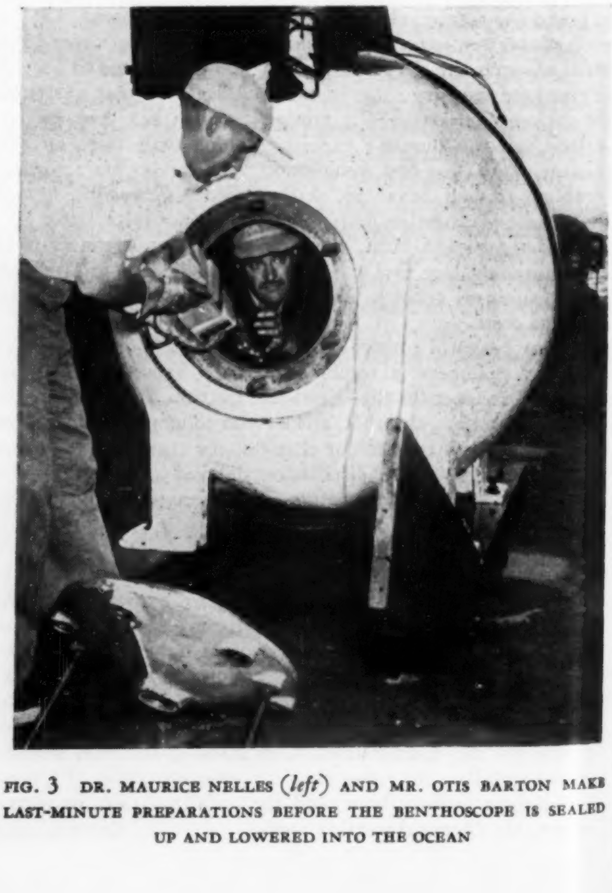


FIG. 3 DR. MAURICE NELLES (*left*) AND MR. OTIS BARTON MAKE LAST-MINUTE PREPARATIONS BEFORE THE BENTHOSCOPE IS SEALED UP AND LOWERED INTO THE OCEAN

in diam. This is large enough for viewing the bottom and for accommodating motion-picture and still-camera equipment which will be used to photograph the bottom which is visible between the two wheels. The quartz windows are approximately 3 in. thick and are set in special types of mounting so designed that as the pressure increases on the windows, the seals become tighter. The door is sealed by means of synthetic-rubber "O" rings and the two flat metal surfaces which are precision-machined.

The air required by the occupants is prepared by making suitable additions and subtractions to the air which is normally in the sphere while at the surface. Oxygen is continually added to the air from cylinders of oxygen. Carbon dioxide and water, which are the products of breathing, are absorbed in solid soda lime. The soda lime is distributed in two trays and air is circulated through the trays by means of an electric fan. If for any reason the electric fan should fail, the occupants can fan the air through the soda lime by means of hand fans.

One main floodlight is affixed to the outside of the benthoscope above the windows. Another floodlight is placed between the two windows. These are special water-cooled lights. One is a 1000-watt light and the other is a 500-watt light. The electricity which is used to light them is furnished by an insulated aluminum conductor which is tied to the main cable as it is reeled out. These lights are controllable from either the surface or the inside of the benthoscope.

A simple and complete communication system is provided so that those on the surface who are servicing the benthoscope can all know immediately what the conditions are inside the sphere.

The actual cost of the benthoscope itself, not including design time and time utilized to make it usable, is approximately $15,000.

People all over the world are becoming more interested in the ocean because it is realized that this will be an extremely valuable source of food supply in the future. From data available at the present time, it seems that the ocean is much more fertile for growing foodstuff than most farms on land. It is also realized that there are probably as many, or more, oil deposits as there are on the main lands. The necessity for developing techniques for utilizing world resources such as these remains to be developed.

The present benthoscope project is divided into three main parts. First, it is planned to test the equipment for making dives into water as deep as 6000 ft. These dives will be primarily to prove the equipment and to make cursory observations. This phase of the experiments will be first conducted in the channel between San Pedro and Santa Catalina Island, and will be concluded in a deep basin in the ocean south of Santa Cruz Island. The second phase of the experiment will be lowering of the equipment in particularly clear water near Emerald Bay off Santa Catalina Island. There is a flat area in this vicinity which contains interesting items for study and is flat enough so that the benthoscope may be rolled along the bottom. This area is less than 1000 ft deep and extra-heavy cable will be used in case obstacles are encountered. The final phase of the project is to lower the equipment into a canyon in the ocean floor. One of these canyons is located near La Jolla, Calif. Extensive studies of these canyons have marked them as being among the most interesting regions in the ocean. It will be an important contribution to science to be able to observe the sides and bottoms of these canyons at depths too great for divers in ordinary diving suits.

On August 15, in the first attempt to dive to 6000 ft, Mr. Barton descended 2300 ft into the Pacific Ocean off Santa Cruz Island, but was balked by failure of the electric power line and

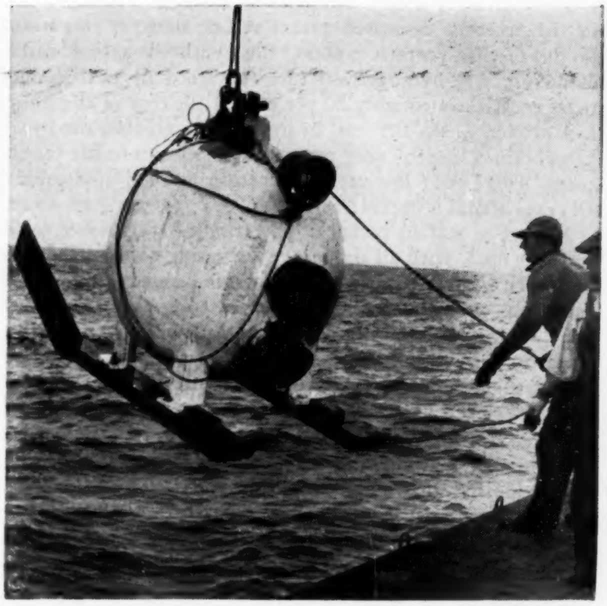


FIG. 4 BENTHOSCOPE BEING LOWERED INTO OCEAN

the electric circulation fan, with a consequent danger of suffocation.

In his second attempt on August 16, however, Mr. Barton went down 4500 ft below the ocean's surface, the farthest man has ever penetrated the ocean depths. Dr. Maurice Nelles, Mem. ASME, kept in constant two-way telephone contact with Mr. Barton from the surface. Dr. Nelles is on the engineering staff of the Allan Hancock Foundation. A power failure again prevented the diver from going down further.

In his dives Dr. Barton reported the discovery of a strange undersea world, populated with phosphorescent shrimps, squid, and eels. The animals swam past the quartz portholes of the benthoscope, flashing their own lights.

The phosphorescent animals were most numerous at about 2000 to 2500 ft, Dr. Barton said. Some of their lights were so bright they reflected inside the benthoscope.

Another record dive was planned, this time to about 6000 feet, as soon as the electrical system could be modified and rebuilt.

Coal Gasifier

A SIGNIFICANT development in the work on synthetic liquid fuels from coal was disclosed by the U. S. Bureau of Mines, with the announcement that a successful full-scale test run had been made in the new coal-gasification unit at Louisiana, Mo. See MECHANICAL ENGINEERING, June, 1949, pp. 499 to 501.

A part of the Bureau's Gas Synthesis (Fischer-Tropsch) Demonstration Plant, this coal gasifier—probably the largest unit ever installed for direct production of synthesis gas from pulverized coal and oxygen—is the second of the plant's five units to be completed. An oxygen-production unit has been in operation for several months, and it is anticipated that the remaining units for gas purification, hydrocarbon synthesis, and product refining will be finished and in operation during 1950.

Gasification, however, is the No. 1 cost and process problem now requiring solution before competitive gasoline and oil can be made from coal by either of the two basic processes employed

in the recently dedicated plants at Louisiana, it was stated. In the Fischer-Tropsch process, the synthesis gas—a carbon monoxide and hydrogen mixture—obtained by coal gasification, constitutes roughly 60 per cent of the cost of the liquid-fuel products. In the coal-hydrogenation process, the hydrogen obtained thereby now represents 40 per cent of the product cost. Therefore a low-cost gasification method applicable to all types of coal is imperative.

As part of a 10-hr period of operation of the gasifier, a 4-hr test was made with all six burners operating at design capacity and with gasifier temperatures averaging about 2200 F. The operation was all that could be expected at this stage of the development, and the shutdown was made voluntarily with no conditions in sight that might have forced it. During this period the feed rates were: coal, 2300 lb per hr; oxygen, 17,000 standard cu ft per hr; steam, 2000 lb per hr.

Approximately 70,000 standard cu ft per hr of gas were made containing the following materials in percentages: carbon monoxide, 37; hydrogen, 42; carbon dioxide, 16; nitrogen, 4; and miscellaneous, 1.

Bureau engineers are hopeful that they can reduce the carbon dioxide content and obtain a higher yield of still better synthesis gas in subsequent runs after they have become familiar with the operating characteristics of the new gasifier.

British Industries Fair

A SURVEY report prepared by A. B. Savage of Great Britain's Board of Trade indicates that this year's British Industries Fair attracted 17,061 overseas buyers, compared with 14,333 in 1948; 124,555 home buyers, compared with 107,000. Both figures are all-time records for the Fair, and are about three times those of prewar days. Exhibitors numbered 3200, and were housed in more space than ever before.

According to Mr. Savage, the "business atmosphere" was good, but orders were not placed with the same urgency as at the previous two postwar Fairs. This does not, in the long run, necessarily mean less business—but it certainly means less easy business.

He pointed out that delivery delays were no longer a deterrent factor, save in a few highly specialized fields, such as capital goods which take a long time to make, or some metal products for which the raw material is scarce.

Exhibitors reported frequent proposals by overseas visitors to manufacture, under license, products shown at the Fair. There is reason to think that some such projects will be carried through.

American and Canadian buyers turned up in greater strength than ever before, he said, and there were encouraging signs that manufacturers who had gone out of their way to study and cater especially for the North American market were rewarded with good business.

The majority of exhibitors were well satisfied as to the value of their participation. Many believe that, as import quotas are relaxed, the amount of business resulting from this year's Fair will be far more than seemed possible before the opening day. In any case, it is usual for the greatest volume of orders to follow weeks after the Fair, and they are nowadays dependent on compliance with complex import formalities. Many exhibitors were surprised at the value of orders obtained from smaller and heretofore unconsidered territories among the hundred or so lands represented by visitors.

Exhibitors reported a surprising number of orders from Egypt, and other notable big buyers were those of India and South Africa. Main target of overseas customers was the heavy machinery; manufacturers of smaller mass-produced articles found the going harder than before.

Building-equipment manufacturers said overseas inquiries were more numerous than last year, and it was possibly their best Fair. A group of exhibitors of stainless-steel sinks, boilers, hospital equipment, and the like, found business quieter than in 1948, but expect a rush of orders whenever the current situation eases. They are, in any case, still fulfilling orders 18 months old.

Heavy electrical gear was much in demand abroad, which compensated some of the larger manufacturers for a decline in the home demand for light electrical goods. Those making nuts and bolts reported "wonderful business" for a commodity in which production is now at full blast, and orders for which can be filled in from two to four months. Much of the same applies to small edge tools, which can be delivered in six months.

Large-scale weighing apparatus, up to 100 tons, sold readily. Hand-toolmakers were up against import restrictions. Orders for sanitary fittings were good. Light engineering firms reported more valuable inquiries, particularly from India, Malaya, and South Africa, than at any other postwar Fair.

A great deal of solid business was done in the textile field, and even more orders taken tentatively, subject to negotiation for import licenses. Opinion about quality seemed to be that it remained at an agreeably high level. Delivery dates presented no great problems, and it was generally acknowledged that design and printing showed further improvement.

Plastics exhibitors reported that they had done well, and some useful inquiries were received in the pottery section. Novel products in leather were well received and in the foodstuffs section overseas buyers were eager to place orders for confectionery. Furniture manufacturers had many inquiries that may develop into positive business, and at least one major project to manufacture abroad under license.

Makers of scientific instruments had a great volume of inquiries, though the trade they would like in the United States is hampered by a high rate of duty. There was a brisk demand for printing machinery, which is one of the few remaining manufacturers held up by fairly long delivery dates.

Next year's British Industries Fair will take place from Monday, May 8, to Friday, May 19, inclusive. The lighter industries will be housed again in London, at Earls Court and Olympia, with engineering and hardware at Castle Bromwich, Birmingham.

Refueling in Flight

REFUELING in mid-air is the solution to long-range flights of both civil and military aircraft, Sir Alan J. Cobham, noted British flier and aviation engineer, said recently at a conference held at the Hotel Commodore, New York, N. Y. Developed in England by Flight Refueling, Ltd., of which he is chairman and managing director, mid-air refueling systems are to be made available by an American company, Flight Refueling, Inc., which has been established at Danbury, Conn., Sir Alan stated.

Giant airplanes capable of carrying enough fuel for nonstop flights of more than 3000 miles, he said, are expensive to build and operate and can carry only about four per cent of their fully loaded weight as useful pay load. Presently available medium-sized planes, Sir Alan noted, can carry a much higher percentage of their all-up weight as pay load for equal distances when refueled in the air.

Research and development work on refueling in flight has been carried on in England for fifteen years by Flight Refueling,

Ltd. It was this company which supplied the equipment for refueling the B-29's on their historic round-the-world flight and which recently kept a Meteor Mark IV jet fighter in the air for twelve hours.

The refueling systems are said to be safe, simple, reliable, and inexpensive. The equipment on the airplane to be refueled consists of fuel lines built into the airframe and usually leading to a single intake. Automatic valves at each fuel tank permit the selective filling of individual tanks or any number of tanks.

The pilot of an airliner equipped for mid-air refueling merely flies on a straight and steady course, and the flight engineer presses a button which lets out a "drogue" or especially equipped fuel line from the tail of the airplane. A tanker approaches from the rear end, and with an automatic probe, makes the fueling connection. The tanks are filled automatically and the flight engineer then presses another button which retracts the drogue.

In military aircraft, the tanker flies in front and carries the hose and drogue which the fighter or bomber picks up. Sir Alan stressed the fact that the fuel is transferred under pressure at rates up to 500 gpm but, due to the closed system, no leakage of fuel or fuel vapors occurs at any time during the operation. A method for refueling three fighters at a time is being developed, Sir Alan stated.

In his opinion, Sir Alan sees in flight refueling a method whereby civil aviation can be made to pay, can be made safe, and relieved from unnecessary landings under trying conditions, and can be helped to operate on schedule at bad times of the year. He also pointed out that the air forces of the United States and Britain will be able to achieve long ranges for both their fighters and bombers at a fraction of the expenditure required without mid-air refueling.

Television Tube Glass

A NEW development in television glass that, it is claimed, will provide for the first time, sharp black-and-white contrast pictures, without dazzling brightness, and which may be viewed equally well in daylight or artificially lighted rooms, was announced by the Pittsburgh Plate Glass Company.

The glass, called teleglas, to be used in the faces of metal picture tubes, provides contrast ratios long sought after by television experts as the ideal range for eye-ease and perfection of image reproduction. It is said to provide television pictures equal to good black and white photographs. Actual contrast range of the new tube face is as good in a well-lighted room as a conventional tube face is in total darkness. Teleglas faces make possible the maintenance of an approximate 35 to 1 contrast under widely varying conditions of room light.

A 35 to 1 contrast means that the high lights of the pictures when viewed with surrounding illumination would be 35 times brighter than the darkest shade obtainable.

Teleglas is reported to be the first practically colorless glass the company has ever manufactured which was designed especially to provide less than a maximum of transmitted light. It acts as a filter to reduce the detrimental effects of room light and to minimize halation—the halos of light formed from internal reflections within the tube face itself.

Eye authorities are in general accord that the main threat of constant television viewing to the eyes comes from concentrating on an overbright image in a darkened room. This practice necessitates contraction and expansion of the retina for the brightness of the screen and the darkness of the room. Since the eyes cannot dilate and contract at the same time, the ideal solution is a not overly bright screen which must, however, have sufficient contrast to give a sharp picture in a lighted room.

Overly bright pictures are conducive to eye strain because the eye muscles must keep refocusing on the screen. Likewise, foggy greys that produce staggering images and hazy outlines give the eyes extra work to do.

Teleglas eliminates the need for costly filtering devices which were formerly placed in front of the tube in attempts to enhance contrast and which were said to be ineffective in controlling halation factors. Dazzling brightness as well as faded greys are eliminated from the picture face itself. The glass is said to perform equally well under a variety of room-lighting conditions.

Seat-Ejection Bail-Outs

AIR Force seat-ejection bail-out tests have recently resulted in successful ejection of personnel from a jet airplane flying at more than 550 mph.

The tests, conducted over San Pablo Bay near Hamilton Air Force Base, San Rafael, Calif., were carried out by test crews of Air Force's Air Materiel Command. The tests are part of a continuing study being conducted by AMC.

The bail-out tests were made at various speeds, and Captain Vincent Mazza was shot clear of the airplane at air speeds of 530 and 555 mph during the latter stages of the tests.

The tests were conducted in the interest of pilot safety and to demonstrate the reliability of the ejection-seat method for emergency escape from disabled aircraft flying at high speed. The bail-outs took place at an altitude of approximately 10,000 ft. A modified version of the standard ejection seat, currently installed in many of the late model U.S.A.F. combat aircraft, was used in the tests.

Emphasizing that the standard ejection seat will be a reliable and safe method for emergency escape from disabled aircraft, Captain Mazza pointed out that he felt no ill effects from the sudden acceleration at the instant of the seat's ejection from the airplane, from the wind blasts striking him as he shot clear of the plane, or from any other forces. He stated that an escaping pilot would easily be able to actuate the manual controls to free himself from the seat and open his chute in case of failure of the ejection-seat automatic control.

The ejection-seat device actually fires the pilot out of the aircraft while he is still strapped to the cockpit seat. The seat is mounted on a tube which extends down its back. This tube fits inside the barrel of the firing mechanism. The pilot is shot from the aircraft as a 37-mm cartridge at the base of the tube is exploded.

After being ejected, the seat is stabilized by automatically operated flaps, and a small drag parachute. This drag chute also rips open the pilot's safety belt; and opens a seat-retarder chute which keeps the seat from becoming entangled with the parachute worn by the falling pilot. The pilot's chute is then opened by a static line attached to the seat.

Gas-Turbine Survey

A WORLD-WIDE gas-turbine survey, said to be the first of its kind, has been compiled by *Power* magazine and appears in the August, 1949, issue of that publication. According to the survey, more than 60 gas-turbine units ranging in size from 150 hp to 27,000 kw, and aggregating more than 410,000 hp, are now operating, under construction, or on order. All engineering data secured from some 24 manufacturers is contained in the report.

The tabulation is divided into four parts: experimental and shop units, stationary, locomotive, and marine plants.

In addition to the units tabulated, Rolls-Royce is building a

plant of undisclosed size for the British Admiralty (for the gunboat "Grey Goose") and Pametrada has under design a 2000-hp gas turbine for compressor drive in a research establishment. In France, Société Rateau is reported to be building a 4660-hp plant for the Ministry of Marine; and Schneider, at Creusot, is stated to be constructing a 5000-kw ship plant. In the U. S., Lima-Hamilton Corporation is developing free-piston units for naval and locomotive applications.

Ultrasonic Instruments

THE Sperry Reflectoscope, Thruray, and Reflectogage, a group of nondestructive testing instruments employing ultrasonic vibrations to locate internal flaws in a wide variety of materials, were discussed by Daniel E. Farmer, electrical-engineering supervisor, Sperry Products, Inc., Danbury, Conn., at the 1948 ASME Annual Meeting held in New York, N. Y.

The basic techniques used in these instruments are as follows: (1) Directing pulses of ultrasonic energy into the material under test and determining the location and extent of flaws by detecting the sound energy reflected to the source; (2) transmitting ultrasonic energy through the material and measuring the relative reduction in the sound transmitted through defective areas; (3) exciting the material under test to vibrate at its natural resonant frequency or amplitude of vibration caused by defects.

The ultrasonic vibrations commonly used range in frequency between one-half million and five million cycles per second, hence these instruments are basically electronic in design and closely akin to television equipment in the engineering techniques used. Major elements include electronic circuits for generating alternating voltages at the frequencies required,

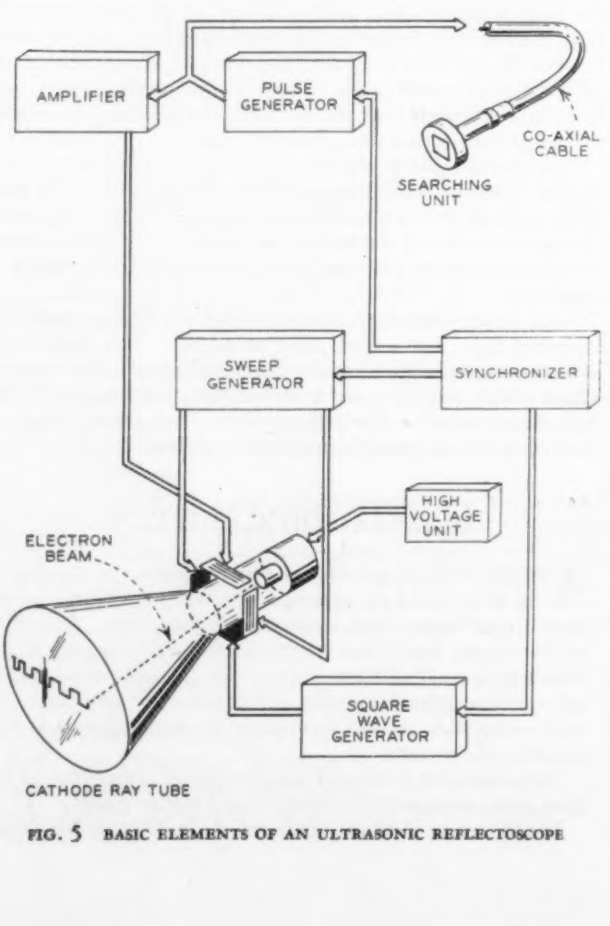


FIG. 5 BASIC ELEMENTS OF AN ULTRASONIC REFLECTOSCOPE

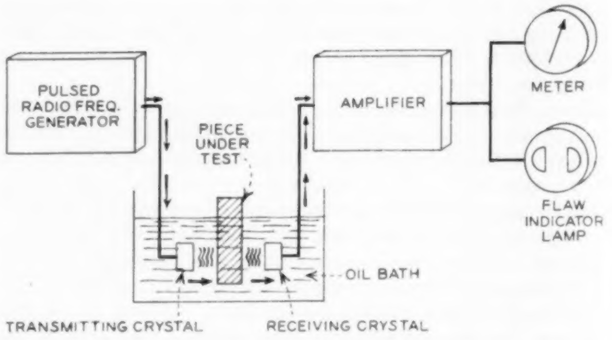


FIG. 6 SCHEMATIC DIAGRAM OF ULTRASONIC THRURAY

means for converting the generated voltage to mechanical vibrations and reconverting these vibrations to electrical voltages, electronic amplifiers for raising the minute voltages to usable magnitudes, and indicators to present the received electrical signals in an intelligible visual form.

Basic elements of a Reflectoscope are shown schematically in Fig. 5. The functions of these elements are as follows: (1) A pulse generator generates a short train of alternating electrical voltage; (2) a searching unit containing a quartz crystal which is made to vibrate mechanically by the electric pulse supplied from the pulse generator. Sound waves are sent out in short bursts from the searching unit and reflected waves picked up by the quartz crystal which then converts the reflected vibrations into electrical energy; (3) an electronic amplifier amplifies the voltages generated to the crystal; (4) these voltages are applied to a cathode-ray tube on the face of which reflected waves are presented in visual form.

Discontinuities in a material under test are separated and identified by measuring the time between sending out the initial pulse of sound energy and receiving the reflected signal. The time scale is related to the distance scale in the material by the velocity and propagation of the sound waves. Timing elements are included to facilitate presentation of the time (distance) base line on the cathode-ray tube and to simplify distance measurements.

Until recently Reflectoscope testing had been limited to inspection of the workpiece along lines at right angles to the available test surfaces. Early efforts to direct sound beams into the workpiece at other angles were thwarted by the enormous reflection losses incurred when the sound beam crossed the boundary between the crystal searching unit and the work. A research and development program was completed by Sperry Products early in 1947 that produced a searching-unit design capable of introducing sound energy into the work at an angle. With this searching unit it is practicable to inspect sheet and plate stock of thinner section than are susceptible to testing at right angles to the surface. By multiple reflections at the surfaces the sound waves are propagated along the sheet material in a narrow beam. Vibrations reflected from discontinuities within the material return to the searching unit along paths similar to the path of transmission and are picked up by the searching unit and presented on the instrument screen. The primary purpose of the development program that led to angle testing was to make it possible to detect defects in welds that could not be discerned by other testing means. Commercial experience, however, indicated that angle testing has a very broad field of application since the reflected sound waves will travel around curves and corners into parts of complicated shapes that are not accessible to testing by any other means.

Through-transmission testing is an alternate ultrasonic

technique for locating defects. The principles of this method are shown schematically in Fig. 6. A high-frequency electronic generator excites a quartz-crystal transducer and the emanating beam of sound energy is directed through the material to be tested to a receiving transducer on the opposite side of the workpiece. The signal received by the latter is amplified and indicated on a transmitter. If the material under test is free from defects there will be reduction in the sound energy transmitted, dependent only on the sound transmission characteristics of the material. Interposition of a defect in the path of the sound beam will diminish the energy arriving at the receiving end and indicate its presence on the meter.

In actual practice, however, it has been found that the reflection testing method, particularly since the development of angle testing, is far superior to through-transmission testing, and consequently Sperry had discontinued manufacture of the Thruray. If a particular application does arise where through-transmission testing is mandatory, Reflectoscopes can be modified for the purpose.

The Sperry Reflectogage, the General Motors Sonigage, and the instruments of other manufacturers licensed by General Motors, operate on the principle of exciting sheet material to vibrate at the natural resonant frequency in the thickness dimension and by indicating the frequency of vibration to indicate thereby the thickness of the material. The components of the Reflectogage are shown schematically in Fig. 7. An electronic oscillator is continually varied in frequency. The oscillator is connected to a quartz crystal transducer which is held against the work. When the frequency of the oscillator passes through the natural resonant frequency of the work, an electrical reaction on the oscillator is produced, amplified, and applied to deflect vertically the bright spot on a cathode-ray tube screen. The spot is swept repetitively across the screen in synchronism with the cycling of the oscillator through its frequency range. The indication of thickness resonance of the work appears as a vertical spike standing on the horizontal base line. The relative horizontal position of the spike on the base line is a measure of thickness of the material. Transparent screens, calibrated directly in thickness of the specific material being tested, are positioned over the cathode-ray tube screen so that the instrument is direct-reading. The Reflectogage will measure the thickness in steel from 0.025 in.

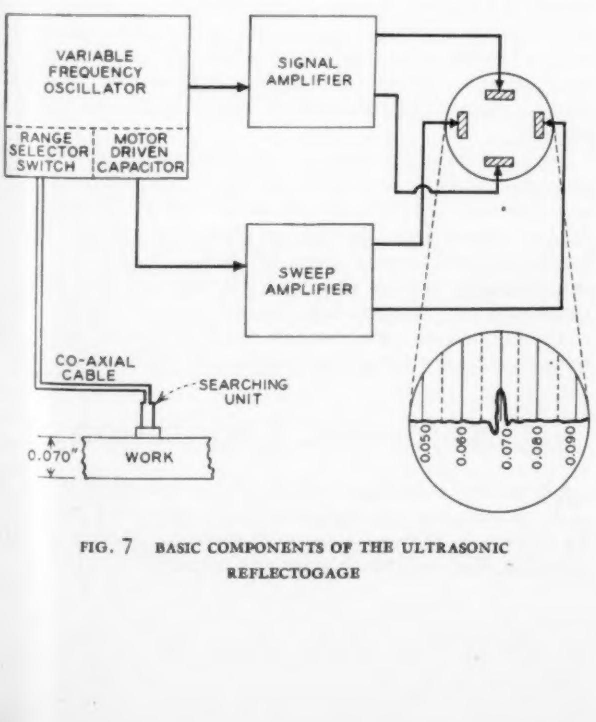


FIG. 7 BASIC COMPONENTS OF THE ULTRASONIC REFLECTOGAGE

to 0.300 in. in four selectable ranges. A number of applications of the Reflectogage have involved its use as a flaw-detection instrument. Disappearance of the resonance phenomenon or radical shift in the apparent thickness of the material under test is evidence of a flaw in the material. The Reflectogage is particularly useful in detecting lack of bond in bonded sheet materials.

The Reflectoscope and Reflectogage are applied to testing ferrous and nonferrous metals, rubbers, plastics, glass, ceramics, and other materials. Production inspection of blooms and billets, heavy castings and forgings, aluminum and magnesium forgings and castings, and extrusions are important applications. Weldments of plate and sheet and bonds of laminates are also inspected. Maintenance inspection to detect fatigue cracks in all types of machinery and structures is an expanding field for ultrasonic testing.

For example, at the same meeting, E. D. Hall, engineer of tests and chief chemist, Erie Railroad, described the application of the Reflectoscope for locating defects in locomotive and car-wheel seats and axles.

Prior to the time the Reflectoscope was available it was found necessary to set up definite limits on axle mileage in an attempt to remove axles before they become fatigued to the point where failure might result.

Unfortunately, so many conditions in locomotive design, maintenance, and operation are of a variable nature that it was found that no definite mileage limit could be estimated for any particular type or location of axle, and that in spite of removing axles on a time or mileage limit, failures in road service still continued.

The practice of removing axles on a definite mileage limit did not prevent all road failures, but on the other hand, did remove from service axles which could have made hundreds of thousands of additional miles before replacement.

In February, 1946, an ultrasonic Reflectoscope was placed in service at the general repair shop at Hornell, N. Y., and every engine receiving classified repairs had its axles and pins tested by this machine. This practice has continued and additional machines have been obtained, which permit inspection to be made in roundhouses without removing wheels from the engine or dropping the rods. Sufficient machines are on hand to permit the testing of all heavy freight and passenger power every two months. Smaller-class engines on short runs pulling smaller trains are tested at slightly longer intervals.

Since the installation of the first machine, 3709 axles have been tested and 99 axles have been found defective; 1576 pins have been tested with 34 being found defective; 112 axles having mileage in excess of 240,000 miles, the previous condemning limit, have been found to be free from defects, and have been left in service. These axles to Sept. 1, 1948, produced 5,374,442 miles of extra service, which would previously have been lost. Sixty-two of these axles are still in service and are producing more free miles. A total of 140 axles have been found defective and removed in all shops including roundhouses. It is highly probable that some of these axles would have caused road failures.

It appears, therefore, that the savings effected by the Reflectoscope in the cost of axles alone is worth while, and that possible service failures have been prevented which may have resulted in derailments costing unknown thousands of dollars, as well as interference with scheduled passenger and freight traffic.

The distinguishing characteristics of ultrasonics are outlined in a paper entitled, "The Theory of Ultrasonic Materials Testing," by H. E. Van Valkenburg, also presented at this same meeting, and appears in full on pages 817–821 of this issue.

Rubber Bearing

DEVELOPMENT of a new rubber bearing which is reported to radically simplify the design of oil-well pumping units was announced jointly by United States Rubber Company and Cabot Shops, Inc.

The new bearing, which is used in the evener assembly, reduces from 100 to 38 the number of parts required for pumping-unit construction.

Field tests in West Texas, Panhandle, and Louisiana oil fields, have shown that the rubber bearing wears at least twice as long as the standard-type installation.

A special test unit with a rubber evener bearing assembly was constructed at Cabot Shops, given a severe unbalanced load, and operated at three times normal field operating speed. The rubber evener bearing, under these unusual operating conditions, completed more than 40,000,000 cycles, outwore many of the structural metal parts in the unit, and still maintained serviceable operating condition. It was also found that the rubber bearing greatly reduced shock load compared to the standard-type bearing.

In addition to the economies made in the simplification of pumping-unit design and longer wear, rubber was selected for bearing construction for the following reasons: (1) rubber eliminates lubrication since the assembly needs no frictionally sliding or roller parts; (2) it is resistant to salt water, sand, grease, and grit; (3) it insulates the gear box from excessive well shocks caused by fluid pounds, gas lock, sanding up, or paraffin; (4) it eliminates the need for elaborate assembly to provide for misalignment because of its self-aligning properties; (5) since rubber flows and flexes within itself, there is no initial friction to overcome and almost no wear as long as flexing is held within rubber's known fatigue limits.

Stainless-Steel Conveyer Belt

AN announcement by Gerald Von Stroh, director of the coal-mining industry's mining-development program revealed that the first test of a stainless-steel conveyer belt was held recently and was successful. It is pointed out that this does not mean that stainless-steel conveyer belts have been developed to the point of commercial utilization. It does mean, however, that the basic fundamentals of the use of such material for conveyer belts is sound. It is expected that further testing and development to make possible even a limited commercial use of stainless steel for conveyers will require another six months. If this development is successful, it will open a new market for stainless steel in the order of 2000 to 3000 tons per year.

The initial tests were conducted at the Johnstown Coal & Coke Company's Crichton #4 Mine in Nicholas County, W. Va. Conventional rubber-belt equipment was used with very slight modifications which actually simplified the unit. The belt was run for several hours. With the use of hydraulic devices, it was given several degrees of loading conditions.

Mr. Von Stroh said that steel conveyer belts had been used in Europe for many years and that as early as 1912 something in the order of 500,000 hp was being transmitted by steel belts. He stated, however, that to the best of his knowledge, stainless steel with its superb properties had not been used in Europe. Mr. Von Stroh felt that the use of stainless steel would overcome many of the limitations of the European steel conveyer belts.

In regard to the effect of this development upon the use of rubber conveyer belts, Mr. Von Stroh felt that the over-all effect would be a considerable increase in the use of rubber belts as a result of the general increase in the use of conveyer belts in materials handling. For example, he pointed out that we would not expect steel belts to function efficiently on steep slopes. There is a definite limitation to the width of stainless-steel sheet that can be rolled continuously. The ideal arrangement in a mine would involve the judicious use of steel and rubber conveyer belts.

At the present time the relative high price of rubber conveyer belts as compared to other types of transportation prohibits their general application in many mines. The combination of stainless-steel belts and rubber belts should bring about an economical picture which would be conducive to the increased utilization of this type of belt in materials handling.

Jet-Engine Testing

A PRODUCTION Westinghouse J-34 jet engine—power plant of the McDonnell "Banshee" U. S. Navy shipboard fighter—has completed successfully the newest 150-hr Air Force-Navy qualification test. It is said to be the first engine of any make or rating to attempt and complete the test.

When the engine was disassembled after the test, its general condition was reported to be excellent and it was fit for further service.

The new qualification test, designated officially MIL-E-5009 far surpasses the performance requirements of the previous Air Force-Navy standard by which the services adjudge the suitability of new aircraft-engine designs for quantity production. Under the test, engines are subjected to "simulated service conditions" continuously for 150 hr. During this time virtually no parts may be replaced and even routine inspections are rigidly limited. Engines must be operated on the test stand through a regular pattern of cycles from idling speed to full military output, and performance carefully charted under a multitude of temperatures, speed, thrust, and other simulated service conditions.

The new test specification, which is designed to assure longer service life and reliability for military aircraft engines under such varying conditions as both tropic and arctic operation, puts much greater emphasis than its predecessor on test performance at so-called "military ratings." During the 150 hr of running, for example, the engine now must operate more than two and a half times as long as before at military rating, which means the top rotational speed, temperature, and stress needed to get a heavily laden combat craft off the ground or give it the bursts of speed needed in combat. It must also endure six times as many rapid accelerations from idling to full speed as formerly.

Every second of the engine's test operation is prescribed and controlled by the step-by-step rules of the specifications: minutes of idling; time to reach full speed; time at full speed; etc. As the engine goes through its seemingly endless cycles of speeding up and slowing down, all its manual, semiautomatic, and automatic controls also get a full work out on a precisely timed schedule. For example, control of the engine is shunted to the engine's emergency system nearly a hundred times, just to be sure that it will be capable of functioning if needed.

Automatic Lubrication

AN automatic lubricant which is both compressible and expansible has been compounded for pressurized plug valves by George F. Scherer, director of research, Nordstrom Valve Division, Rockwell Manufacturing Company.

This energizable lubricant is said to store energy within itself, which, when released, produces automatic lubrication. The lubricant seals the seating surfaces and fills any void that might occur within the valve. It stores the energy for multiple valve turnings and when exhausted it can be re-energized by adding more lubricant to the reservoir or by simply turning the lubricant screw.

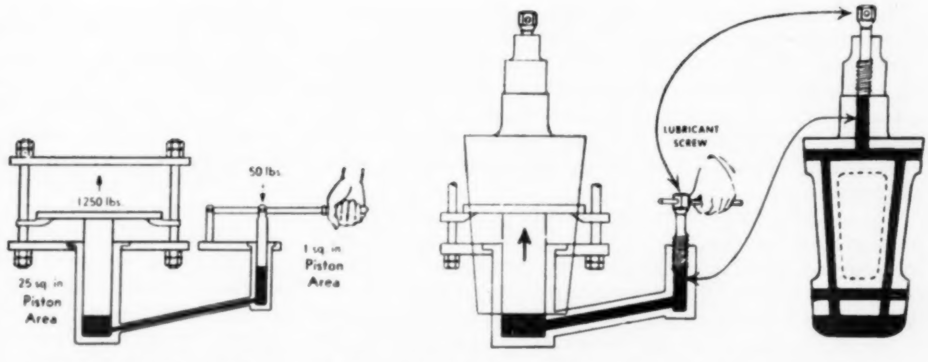
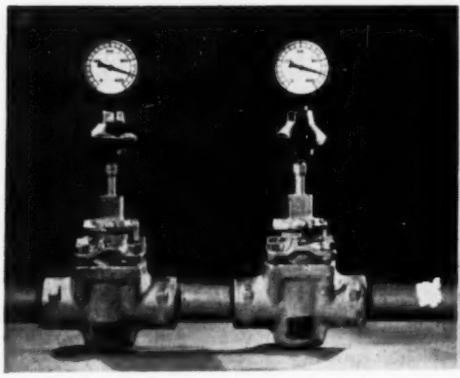
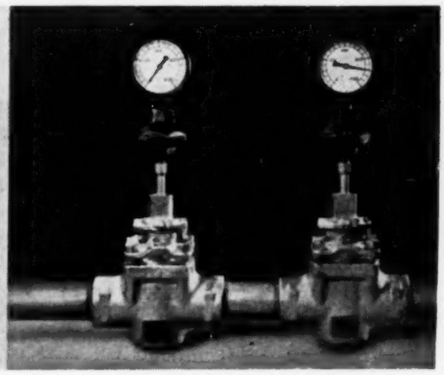


FIG. 8 PASCAL'S LAW OF FLUID DYNAMICS AS RELATED TO PLUG VALVES OF THE PRESSURIZED TYPE

(The law states that "pressure applied to a confined fluid is transmitted uniformly to all areas of the confining surface.")





a *b* *a* *b*

FIG. 9 (*left*) COMPARATIVE TESTS SHOWING PRESSURE RETENTION

[Valve (*a*) is pressurized at 350 psi with nonenergized lubricant on a test line. Valve (*b*) of identical type is pressurized to 350 psi with automatic energized lubricant.]

FIG. 10 (*right*) SAME VALVES SIX MONTHS LATER

[Valve (*a*) pressure of nonenergized lubricant has dropped to 0 psi. Valve (*b*) pressure of energized lubricant shows negligible decline.]

The new lubricant, called Hypermatic, can be immediately applied by users of Nordstrom-type valves now in service. No investment in mechanical devices or equipment is required in order to convert the valves to automatic lubrication.

To date, tests have been confined to valves, but later tests may reveal other uses. Field tests on valves indicate that the energizable lubricant functions under most conditions in a temperature range to 250 F.

Compared to a standard lubricant, which is incompressible and maintains pressure within the valve only for a short time, Hypermatic continues to exert pressure to fill lubrication voids until the confined pressure drops to a minimum of 50 lb. The time during which the valve maintains 100 per cent automatic lubrication without repressurization depends upon the number of valve closures and the amount of lubricant stored within the valve. Full automatic lubrication may be restored simply by adding more Hypermatic either by insertion of the material in stick form or by a high-pressure grease gun.

The self-acting lubricant is held in its energized condition between the valve sealing surfaces and the ball check valve in the stem of the valve. Should the valve be neglected over a long period of usage and the energy of the lubricant become dissipated, this material simply reverts to the status of a nonautomatic lubricant.

Three advantages for the users of automatic lubrication are claimed: (1) Decreases the frequency of valve lubrication, (2) keeps the valves in a state of 100 per cent lubrication, and (3) maintains the valves in operable condition without first stopping to relubricate the valve.

Basically, the new lubricant is similar to standard noncompressible materials in its lubricating properties and wetting action. It is available in stick or bulk, just as standard valve lubricants. The main difference between this automatic lubricant and nonautomatic types is its intrapowered action under working conditions. The lubricant flows into voids and maintains an unbroken film surface. When it comes to rest, as when the valve turning is complete or any void is filled, it again assumes its plastic form with all lubricated surfaces.

Only the normal valve adjustments need be made to hold the energized lubricant. It is unnecessary to purge the lubricant from valves already in use. The old lubricant is gradually forced out over a period of time. Automatic lubrication is reported to be effective over the entire range of pressures that are recommended, including vacuum service.

Steel Production

AMERICAN steel companies spent $3.2 billion to expand in the decade of the 1940's; capacity was increased 16 million tons; and 800 million tons were produced, according to *Steel Facts*, August, 1949. The industry paid nearly 17 billion dollars to employees in that period.

In many other ways, too, the ten years of the 1940's, now nearing their close, stand out as the greatest in the history of the steel industry. Passing through rearmament, war, reconversion, and the postwar boom period, the steel industry met all the varied demands confronting it, despite such obstacles as man-power shortages, difficulties in getting equipment, raw-material shortages, strikes, and other problems.

The 800 million tons of raw steel made in the 1940's was more than twice the amount produced in the 1930's and 70 per cent above the output of the 1920's. In fact, the percentage gain of the 1940's over the 1930's was by far the greatest of any decade in this century. To make that huge tonnage of steel, more than one billion tons of iron ore were utilized, 875 million tons of coal, 440 million tons of scrap, and vast quantities of other materials.

The industry added more than 16 million tons to its annual ingot capacity in the decade of the 1940's, compared with 9 million tons in the preceding ten-year period, and 10 million tons in the 1920's. For expansion and improvements the industry spent $3.2 billion during the 1940's. In the latter part of the 1930's there had been much talk in some quarters outside the industry as to whether steel capacity had been overexpanded.

Monthly production of raw steel attained a record exceeding 8 million tons early in 1949, compared with output between 4 and 5 million tons in most of the early months of 1940 when operations fell swiftly, about 30 percentage points in five months, to 61 per cent of capacity. Before 1940 ended, however, operations had risen above 6.6 million tons a month, with the operating rate surpassing 96 per cent.

The amazing record in demand, production, and expansion has been facilitated by equally sweeping changes in technology, marked by the increased size of furnaces, the growth of automatic process controls, hardenability controls, and many other developments.

Meanwhile electric-furnace steel production grew rapidly, a reflection of the increased use of alloy steel. It attained a record of 14.8 per cent of total steel output in 1943. Since the war it has run a little less than 10 per cent of total output. Production last year was nearly 8.5 million tons of alloy ingots and steel for castings, compared with slightly less than 5 million tons in 1940.

Included in the alloy situation is the rapid expansion in the use of stainless and heat-resisting steel. Prior to 1940 the annual output of stainless ran less than 200,000 tons, but in that year it rose to nearly 250,000 tons, and in 1948 reached 617,000 tons.

Rolled products also have passed through sweeping changes in regard to quality and relative tonnages. In the first decade of the century the heaviest single tonnage was in rails, making up nearly one fifth of the total output of hot-rolled products. In the second decade more emphasis was directed toward plates, which made up one eighth of the total. In the 1920's the increase in production was led by sheets and black plate.

With the rising demand for sheets in consumer goods came the development of the wide continuous sheet mill. From 1929 to 1939 the number of such mills rose from seven to 27.

Since the war, sheets have risen to one quarter of production, not including sheets and strip for black plate and tin plate. The gradual change in emphasis from heavy to light steel through five decades reflects the growth in use of steel in automobiles and other consumer durable goods.

Despite the expansion in continuous mills and other mass-production aids, wage earners employed by the steel industry increased from 400,000 in the middle 1920's to 425,000 at the end of the 1930's, and to more than 500,000 in recent months. The postwar peak came in February, 1949.

Cryogenics Laboratory

A NEW cryogenics laboratory at the Westinghouse Electric Corporation is producing custom-made temperatures all the way down to 458 deg F below zero, according to Dr. Aaron Wexler, head of low-temperature studies at the Westinghouse Research Laboratories, Pittsburgh, Pa. Using special techniques, the scientist can come within one tenth of a degree of absolute zero—459 deg F below zero.

"At such temperatures," Dr. Wexler explained, "the nature of matter undergoes radical changes and behaves in a most mysterious manner. For example, liquid helium flows uphill and the flow of electricity in a wire encounters no resistance at all. Although these facts have been known for years, scientists are striving to find out why this should happen.

"Our quest is aimed at uncovering fundamental explanations of this mysterious behavior at subzero temperatures."

One major mystery now under attack was the resistance-free course that extremely low temperatures provide for electricity.

Normally, electricity flowing through a wire will meet resistance and lose some of its power in the form of heat. But if you immerse the circuit in liquid helium—with a temperature of about 452 F below zero—it will continue to carry current even though the source of electricity is shut off.

This strange behavior, which scientists call superconductivity, may be of great significance to future power transmission, Dr. Wexler said. If it could be properly harnessed, it might mean much more efficient and cheaper distribution of electricity. A thorough understanding of the nature of resistance-free conductivity may be the key to unlock this door.

Only certain metals—13 of them thus far—are superconducting at subzero temperatures, he said. Among the most important of these are columbium, tantalum, vanadium, and their alloys, because they become resistance-free at temperatures that are relatively "high."

Pure columbium will conduct electricity without resistance at a temperature of 16 deg above absolute zero, while its nitride will perform the same feat at 29 deg above. A major aim of this research is to find metals or alloys that are superconducting at higher and higher temperatures—thus reducing the problem of refrigeration.

Dr. Wexler's laboratory takes helium gas in at one end and in a series of steps produces liquid helium at the other—with a temperature of 452 F below zero—about 8 above absolute zero. Additional methods bring this down to a mere fraction of a degree above absolute zero.

All through the process, electronic and mechanical controls take over. This enables the scientist to keep a constant check on the subzero-temperature production. The helium gas is stored in tanks that line the ceiling of the laboratory, while the liquid helium is returned to its gaseous form after use and recirculated into the storage tanks.

The scientist ranked low-temperature research on a par with nuclear physics as a factor in unearthing new information on the ultimate structure of matter.

Underground Gasification

THE promising potentialities of underground gasification of coal as a source of cheap fuel for power generation and as a method of utilizing coal veins at present difficult or uneconomical to mine was one of the principal topics of discussion during the meetings of the Fuels and Energy Section of UNSCCUR—the United Nations Scientific Conference on the Conservation and Utilization of Resources, held Aug. 17, 1949, to Sept. 6, 1949, at Lake Success, L. I., N. Y.

Under the chairmanship of Reymond Cheradame of the Centre d'Études et Recherches des Charbonnages de France, participating scientists and experts heard two papers on this subject.

The first, jointly offered by M. H. Fies of the Alabama Power

Company and James L. Elder of the Bureau of Mines of the United States Department of the Interior, dealt with the United States efforts in "Laboratory and Field-Scale Experimentation on the Underground Gasification of Coal."

Mr. Elder, who presented the paper, explained that the U. S. Bureau of Mines and the Alabama Power Company had been conducting experiments in underground gasification in Gorgas, Ala., since 1946.

The latest phases of the experiments were directed at determining the quantity of coal that can be gasified from the given initial combustion zone and the shape and extent of the burned out area formed during this gasification.

In addition, information was being gathered in regard to the design and characteristics of the various types of equipment used.

Underground gasification of coal has "promising potentialities" as a method for obtaining low-cost gas, he declared. It would eliminate two basic costs common to other processes, the mining of coal and the installation of gas generators. Furthermore, said Mr. Elder, underground gasification held "alluring possibilities" as a source of cheap fuel for power generation and as a method of utilizing coal veins difficult or uneconomical to mine.

In this connection, he said in conclusion, information obtained so far appears to indicate that producer gas having a heating value of 125 Btu per cu ft can be developed at a cost which may be "as low as 14 cents per million Btu produced." This is the equivalent to a coal cost of $3.50 per ton at the mine.

The second paper was prepared by M. Doumenc, professor at the School of Mining at St. Etienne, France, but in his absence it was presented by Mr. Cheradame, the chairman.

Before reading Professor Doumenc's paper, the chairman recalled that the first experiments in underground gasification had been carried out in the USSR.

It appeared, however, that the practical results obtained from these Soviet experiments had not been entirely satisfactory, he said. It was known, for instance, that for the USSR's 5-year plan of 1946–1950 it was planned to obtain 920,000,000 cubic meters of gas by this method. This was the equivalent of approximately 250,000 tons of coal, which was not a "very high figure."

Summarizing Professor Doumenc's paper, Mr. Cheradame explained that French research in underground gasification at present included: (1) An underground experimental plant in Morocco, (2) participation in joint Franco-Belgian experiments at Bois-la-Dame, Belgium, and (3) research conducted at the experimental station of the Charbonnages de France at Montlucon.

It was hoped that these experiments and, in particular, those in Morocco, would yield enough data to set up a semi-industrial plant in which to investigate the economic aspects of production.

The technical importance of underground gasification, declared Mr. Cheradame, depended on the extent to which cheap producer gas could be generated. Thus, he added, the economic value of any attempt to improve the quality of the gas, whether for synthetic purposes, or to enable it to be transported long distances, would reside in the low cost of the basic material.

Under present circumstances, producer gas could not be produced at less than one franc per cubic meter. This figure, said Mr. Cheradame, in conclusion, was double that required if the process was to be economical.

In the brief discussion that followed, E. G. Bailey, past-president and Fellow ASME, declared that the main problem in underground gasification at present seemed to be assuring a continuous reaction system.

In this connection, he added, the chain reaction achieved by the atomic scientists should serve as an example. Under ideal conditions, he said, many thousands of acres should be used under this method for a period of at least 20 years, with no more controls necessary than those over "what was going in at one end and coming out the other." If industry, geologists, and engineers really co-operated on this project, said Mr. Bailey, all related problems would be solved in the near future.

A. Ignatieff of the Department of Mines and Resources, Canada, also believed that underground gasification methods could become practical realities in the near future. However, he stated, it was evident from the large scope of the project that it would require considerable assistance from governments.

He recalled that the first experiments on these methods had been carried out in the USSR, but even there, he pointed out, they were "still strictly in the experimental stage."

He then said that earlier tests had been mainly directed at obtaining an "optimum" type of gas, while later experiments, and particularly those carried out in the United States and by the French in Morocco, appeared to be directed at achieving "continuous operation." This, he said in conclusion, was the "chain reaction" that Mr. Bailey talked about.

Paul L. Alspaugh, of the Carbide and Carbon Chemicals Corporation of West Virginia, stressed the conservation aspect of underground gasification methods.

From the point of view of practical economy, he said, this method did not appear to be satisfactory for "thin seams" or mined-out areas. Its only practical use appeared to be limited to "dirty seams." However, he added, under present circumstances he did not see how energy gas could be produced economically even from "dirty seams."

Mr. Alspaugh believed that the only ultimate possibility for this method to compete with present-day mining systems resided in the possible production of chemical by-products.

C. E. Potter, of the U. S. Department of Agriculture, said that progress of underground gasification was essential to United States interests. He pointed out that past estimates of the energy resources had been incorrect, and new estimates proved the necessity of acquiring new energy sources or developing to a greater extent those already in existence.

At present, he stated, because of the competitive nature of the industry, coal mining was "leaving as much in the ground as it is taking out." The day was near when these unmined or abandoned areas would have to be exploited again. It was for this reason that further work on underground gasification should continue "not for tomorrow nor for the next week, but for now."

Stratosphere Data

DETAILED soundings of stratospheric temperature and humidity at 99,000 ft have been obtained with a new instrument perfected by University of Chicago scientists, under sponsorship of the Office of Naval Research.

The instrument was borne aloft by a new type of plastic balloon, marking the first time that accurate and continuous moisture determinations have been obtained from a free balloon in the stratosphere.

The new altitude attained is about twice that at which accurate measurements of humidity had previously been made. Formerly used instruments, known as radiosondes, were not dependable in the low-vapor concentrations and cold temperatures of the stratosphere.

The information, transmitted to receivers on the ground, is valuable not only to meteorologists and astronomers, but also to aeronautical engineers in the designing of safe and efficient aircraft for high-altitude flying.

ASME TECHNICAL DIGEST

Substance in Brief of Papers Presented at ASME Meetings

Steam Power

Steam-Electric Power Expansion in Southern California, by W. L. Chadwick, Mem. ASME, Southern California Edison Company, Los Angeles, Calif. 1949 ASME Semi-Annual Meeting paper No. **49—SA-16** (mimeographed) to be published in Trans. ASME).

California may be said to consist economically of three metropolitan and industrial areas and a large agricultural hinterland in which there are also some industrial and residential centers. The metropolitan areas of course are that around San Francisco Bay in northern California, and those around Los Angeles and San Diego in southern California. Although geographically, southern California includes only ten of the State's 58 counties and only 37 per cent of the area of the State, it contains more than one half of the State's population and utilizes about one half of the electric power. Another fact which has a large bearing on power resources, particularly hydraulic power, is that the southern California area possesses only about 1 per cent of the State's water resources.

This paper presents the background of the postwar expansion of steam power in southern California, the requirements of the area served, a brief discussion of some of the war and postwar influences bearing on power needs, the disposition of the new generation, the design trends in the area and the influences bearing thereon, and a description of the major features of the Redondo Steam Station of Southern California Edison Company. Prepared discussions present the major features of the Harbor Station of the Department of Water and Power, City of Los Angeles, and the Silvergate Station of the San Diego Gas and Electric Company.

Heat Rate Test Results of the 100,000-Kw Essex Turbine Generator, by V.S. Renton, Mem. ASME, Public Service Electric & Gas Company, Newark, N. J., and Stanford Neal, Mem. ASME, General Electric Company, Schenectady, N. Y. 1949 ASME Semi-Annual Meeting paper No. **49—SA-19** (mimeographed).

A 3600-rpm, tandem-compound, 100,000-kw turbine generator was recently installed at the Essex Generating Station of the Public Service Electric and Gas Company of New Jersey. Since it was, at that time, the largest machine of its type ever built, the first of a new class, and had initial steam conditions of 1250 psig and 1000 F, careful and extensive heat-rate tests were made jointly by the operating company and the manufacturer.

At the best point which was at 93-mw load, and at an exhaust pressure of $1^1/_2$ in. Hg abs, the heat rate of the turbine-generator and feedwater heaters was found to be 8498 Btu per kwhr for the standard cycle used to compare the test points. The corresponding thermal efficiency is 40.16 per cent. The standard cycle differed from the operating cycle only by a few tenths of a per cent.

At the rated exhaust pressure of $1^1/_2$ in. Hg abs, the heat rate averages 0.76 per cent better and the best point is 1.4 per cent better than guaranteed.

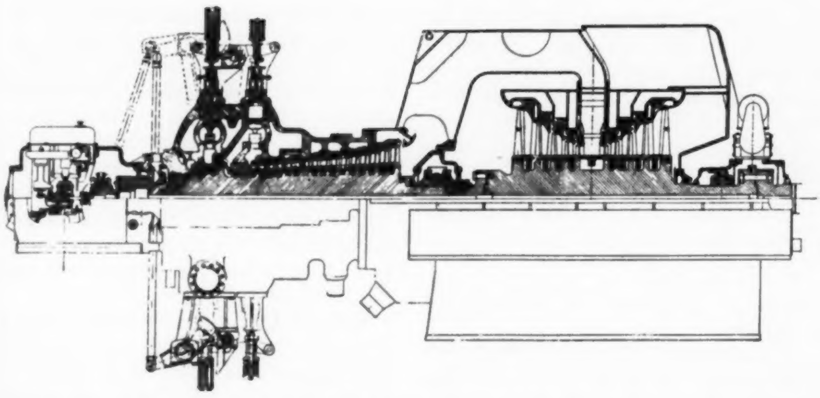
Test data on the complete unit including boiler, turbine, feedwater heaters, and auxiliaries indicate an approximate over-all heat rate of 10,100 Btu per kwhr at the most economical point during winter conditions. The corresponding thermal efficiency is 33.79 per cent. With 13,500-Btu per lb coal, that heat rate corresponds to the consumption of 0.75 lb of coal to produce one net kwhr of electric energy at generator terminals.

During 1948 the station records show that the over-all unit heat rate was 10,500 Btu per kwhr at an average load of 97,800 kw for each hour of operation.

Tests of the operating characteristics have demonstrated that the unit operates satisfactorily with fast starts and high loading rates. Several load dump tests followed by fast pickup of load have been made with excellent performance.

Operating Characteristics of the 100,000-Kw Essex Turbine Generator, by Stanford Neal, Mem. ASME, General Electric Company, Schenectady, N. Y., and V. S. Renton, Mem. ASME, Public Service Electric and Gas Company, Newark, N. J. 1949 ASME Semi-Annual Meeting paper No. **49—SA-28** (mimeographed; to be published in Trans. ASME).

Since the 100,000-kw Essex turbine



SEMISECTION OF UNIT NO. 1 TURBINE AT THE ESSEX GENERATING STATION OF PUBLIC SERVICE ELECTRIC AND GAS COMPANY

generator was the first of a new class of turbines for both the manufacturer and the operating company, and since the throttle steam temperature was 1000 F, extensive tests were made to determine practical operation procedures for the new machine.

These tests indicate that, even with the high steam conditions of 1250 psig, this 1000-F turbine generator can safely withstand starting and loading rates higher than those normally used. The operating instructions for this machine can be revised to take advantage of these characteristics. Additional data are needed for wider application to other machines and designs.

Although the analysis is not complete, the following procedures are justified by the test data and are consistent with previous experience. They are recommended specifically for the Unit No. 1 Essex turbine generator.

1 In an emergency, a load of any size can be dropped instantly and after no-load synchronous-speed operation for as long as 45 min, with $1^1/_2$ in. Hg abs exhaust pressure, the turbine generator can be loaded as fast as dry steam can be supplied.

2 Conservative starting and loading practice is determined by the rates at which temperatures throughout the machine will approach their steady-state values. Recommended starting times and loading rates are as follows:

Initial turbine temperature	Starting time	Loading rate
150 F	50 min	1 mw/min
450 F	20 min	3 mw/min
750 F	10 min	5 mw/min

3 Loading or increase of throttle-steam temperature can be done safely with respect to both expansion and temperature changes. With the turbine at any steady-state load, load can be increased to any other load at the rate of 5 mw per min at constant throttle temperature, or throttle temperature can be increased by 200 F at the rate of 500 F per hr at constant load.

4 Unloading or decrease of throttle-steam temperature must be carefully considered since the rotor contracts faster than the shell. The cooling gradients are usually low and uniform. As long as dry throttle steam is supplied, any amount of unloading can be done at the rate of 5 mw per min at constant throttle temperature, or throttle temperature can be dropped 200 F at the rate of 500 F per hr at constant load. The safest unloading procedure at any time consists of dropping all load instantly. During any unloading cycle, the throttle temperature should be held as high as possible.

5 The generator starting test results show that there are no restrictions on starting time or loading rate of the generators, although it is recommended in the interests of longer life and lower maintenance that the main generator field be preheated with an 850-amp current for 20 min immediately prior to operation at speeds above 1200 rpm.

Applied Mechanics

Atomization of Liquids by Means of a Rotating Cup, by J. O. Hinze and H. Milborn, Royal Dutch/Shell Group, Delft, Holland. 1949 Semi-Annual Meeting paper No. **49—SA-2** (in type, to be published in the *Journal of Applied Mechanics*).

Liquid, supplied through a stationary tube to the inner part of a rotating cup widening toward a brim, flows viscously in a thin layer toward this brim and is then flung off, all by centrifugal action. The flow within this layer and the disintegration phenomena occurring beyond the brim have been studied, experimentally as well as theoretically. A formula has been derived for the thickness and for the radial velocity of the liquid layer within the cup, which proved to agree reasonably well with experimental results. Three essentially different types of disintegration may take place around and beyond the edge of the cup designated respectively, by: (*a*) the state of direct drop formation; (*b*) the state of ligament formation; and (*c*) the state of film formation. Which one of these is realized depends upon working conditions. Transition from state (*a*) into (*b*), or of state (*b*) into state (*c*) is promoted by an increased quantity of supply, an increased angular speed, a decreased diameter of the cup, an increased density, an increased viscosity, and a decreased surface tension of the liquid. The experimental results have been expressed in relationships between relevant dimensionless groups. For the state of ligament formation a semiempirical relationship has been derived between the number of ligaments and dimensionless groups determining the working conditions of the cup. Results of drop-size measurements made for the state of ligament formation as well as for the state of film formation show that atomization by mere rotation of the cup is much more uniform than commonly achieved with pressure atomizers.

Performance of the Viscously Damped Vibration Absorber Applied to Systems Having Frequency-Squared Excitation, by F. M. Sauer, Jun. ASME, and C. F. Garland, Mem. ASME, University of California, Berkeley, Calif. 1949 ASME Semi-Annual Meeting paper No. **49—SA-5** (in type; to be published in the *Journal of Applied Mechanics*).

The effectiveness of the viscously damped vibration absorber is presented for the case in which the magnitude of the periodic exciting force acting upon the main system is proportional to the square of its frequency. Dimensionless expressions for the amplitudes of the main mass and absorber mass and for their phase relationships are derived as functions of frequency for three cases, namely, one in which the absorber is tuned to the natural frequency of the main system, one in which the absorber is tuned for maximum effectiveness over a wide range of forcing frequencies, and one in which the absorber is coupled to the main system by a viscous fluid only (the viscous Lanchester damper). The influence of main-system damping upon the amplitude of vibration of the main mass is shown for each case. Diagrams are presented showing the optimum damping, the maximum amplitude of the main mass, and the maximum relative amplitude between the main mass and absorber

mass, as functions of the mass ratio. The performance of the absorber when applied to the system having velocity-squared excitation is compared with its performance when applied to the system having constant exciting force, published previously. The tuning and damping for optimum performance are found to be different in the two cases. A model absorber with controllable tuning and damping, constructed for experimental work, is described and experimental data are presented for the case of most favorable tuning.

Boiler Feedwater Studies

The Quality of Steam Condensate as Related to Sodium Sulphite in the Boiler Water, by R. C. Alexander, Department of Water and Power, Los Angeles, Calif., and J. K. Rummel, consulting chemical engineer. 1949 ASME Semi-Annual Meeting paper No. **49—SA-37** (mimeographed).

Test data and conclusions are submitted which relate to the effect of various concentrations of sodium sulphite on the quality of condensed steam from high-pressure central-station boilers. Increase in sodium sulphite beyond certain limits was found to lower appreciably the pH and to raise the conductivity of the condensed steam. The acid material found in the steam resembles sulphurous acid. Test data, procedures, and equipment are described.

Based on the data obtained from boilers operating at 900 psi and over, the following conclusions have been reached:

It is probable that when more than 5 ppm to 8 ppm of sodium sulphite is present in the boiler water, the quality of the steam will be affected.

The extent to which the composition of the steam is changed will depend largely on the concentration of sodium sulphite, and to some degree on the alkalinity and pH of the boiler water.

The change in steam quality is seen in the lowering of pH, increase in the conductivity, and increase in the reducing material of the steam condensate.

A large part of the reducing material found in the steam condensate resembles sulphurous acid.

When the steam contains sufficient ammonia or other alkaline material to overbalance the acid effects of carbon dioxide, it is probable that with small amounts of sodium sulphite in the boiler water, the point of lowest conductivity of the steam condensate will be near a pH of 8. Near this point, increasing the sodium sulphite concentration will lower the pH and raise the conductivity of the condensate, but lowering of the sodium sulphite will increase both the pH and conductivity.

The test data which are presented are of special interest when using conductivity readings to estimate the solid-matter content of the steam condensate and in regulating the amount of solid matter in the form of acid-reducing material.

The quality of the steam from boilers operating at pressures below 900 psi, should be studied further, in order to show the effects of sodium sulphite in the boiler water.

Management

Optimum Speeds of Indexing Devices, by D. G. Malcolm, University of California, Berkeley, Calif. 1949 ASME Semi-Annual Meeting paper No. **49—SA-34** (mimeographed).

Though industry is using an increasing number of machines whose speeds are controlled by the operator's capacity rather than by the machine's, little or no consideration is being given to the operator's capability when machine speeds are set.

The speeds of operator-fed machines ought to be adjustable, and if possible, set at the speed which will allow each operator to perform at his optimum rate.

Recently the effect of machine speed on the performance of operators was tested. The paper points out that similar tests could be helpful in industry for determining the proper machine speeds. On the basis of the laboratory research the following conclusions were drawn:

First, the operator's subjective feeling concerning his production rate is misleading as an estimate of his actual production rate. Second, the "production versus machine-speed curves" for all operators are similar, showing a gradual leveling off of production as speed is increased, a peak, and finally a sharp drop. Third, all operators but two reached peak production when their machines were operating at approximately the same speed. The two who lagged had difficulty training their left hands. This suggests that the variation in speeds at which maximum production is reached would be much smaller with operators more fully trained than the students used in the experiment.

Assuming that the principles brought to light in the experiment are valid in the industrial situation, the following suggestions were made to industry:

Whenever the machine's speed is determined by the operator, school him in the fact that his total production will continue to rise as he increases the machine speed even though he misses more opportunities and feels that he is producing a smaller amount. This is necessary because too often his subjective feeling will cause him to settle for a speed below his optimum. If a piece-rate wage incentive is used, this new approach should not be hard to prove to the operator.

When a supervisor is responsible for setting the machine speeds, it is suggested that experiments be made to determine the speeds at which each operator can produce the most. The maximum production speeds very likely will be quite similar, but each machine still should be set at the individual operator's optimum speed.

When machines of this type are not adjustable, it would be wise to have machine designers incorporate the adjustable feature. Each operator should have the opportunity to adjust the machine he is working at to his optimum speed. Allowance should be made for individual differences that exist in the workers who operate production machinery.

Have Wage Incentives Been Oversold? by Douglas Watson, Jun. ASME, McKinsey & Company, management consultants 1949 ASME Semi-Annual Meeting paper No. **49—SA-38** (mimeographed).

A wage-incentive plan alone is an imperfect cost-reduction tool for the smaller company or under conditions of rapid technological change. Even though its immediate results may make it very attractive to management, it requires careful planning and administration by capable technicians and better-than-average supervisors to be successful.

Ideally, the installation of a wage-incentive plan should follow improvement and standardization of methods and organization, improved tooling, near-perfection shop scheduling and control, and adequate machine maintenance. Even when this is done there are always technical problems remaining in defining "a fair day's work" and "an average level of output."

A wage incentive paid to direct employees brings up a compensation problem with the indirect workers, a problem which has no ready easy solution.

If we are to reduce costs and become competitive, we must look to other management tools than just a wage-incentive plan. Although they are attractive at first glance, the problems of administration are such as to make wage

incentives alone an unsatisfactory means to reduce labor costs.

Re-establishment of the foreman as a true supervisor through providing him with adequate standards and management guides will permit and encourage effective cost reduction.

The receptiveness of the foreman to improved methods is increased, and his interest in having an economical production unit is stimulated.

Lower-level planning and control encourage the foreman to emphasize those intangible factors that develop an operator's interest in his job. Motivation of this kind is found to be increasingly more effective than a wage incentive alone.

Wage incentives have been oversold as a cost-reduction tool. Under a properly applied incentive, production costs are frequently lower, but most of the cost reduction can be traced to management's efforts to make the incentive workable, not to the incentive itself. As a means of rewarding the better-than-average worker, a sound wage-incentive plan is an excellent management technique. But to reduce costs—look to the properly guided foreman.

Production Management in Small Business, by Frank K. Shallenberger, Stanford University, Stanford University, Calif. 1949 ASME Semi-Annual Meeting paper No. **49—SA-43** (mimeographed).

This paper is an investigation of production management in small business, the objective being the development of practical approaches to increased productive efficiency. Consideration is given to the advantages, disadvantages, and special problems of the small manufacturer. Functions of production control, stores control, quality control, cost control, methods improvement, performance standards, tooling, layout, shop housekeeping, and safety are considered and where feasible, recommendations made for developing techniques and procedures appropriate to the small operation. Potential outside sources of production-management assistance are suggested and evaluated. The creation of a new position, that of "manufacturing controller," is proposed.

It is concluded that for the most part operators of small plants fail to utilize effective management controls, preferring to rely on personal controls alone. They avoid paperwork and overhead which do not immediately, clearly, and directly increase profits. The individual who has made a success of his industrial venture typically does not seek and may actually resent outside ssistance. Yet he usually fails to grow organizationally to provide that assistance from within.

It is clear that effective management controls are essential to efficient plant operation and will be increasingly so over the next few years. It is further clear that the small plant cannot afford and does not need the elaborate control procedures typical of the large concern. There are, however, certain proved control techniques well adapted to small-company operation. Coupled with the intimate personal contact typical of the small plant, they will provide effective control over production at a cost which the small company can afford. For the most part, regular line personnel can assume the responsibility for operating these controls, but in many cases the employment of a "manufacturing controller" will be justified. Valuable outside aims are available at little or no cost.

It remains for each small operator to take advantage of these opportunities so that his company may be numbered among those which will succeed in the competitive battle already at hand. This is a good time for small-plant management to step back from details and take a good over-all look at all phases of the business.

Railroads

Motor-Generator Locomotives, Their Design and Operating Characteristics, by J. C. Fox, Mem. ASME, The Virginian Railway Company, Princeton, W. Va., F. N. Gaynor, Great Northern Railway, Wenatchee, Wash., and F. D. Gowans, Mem. ASME, General Electric Company, Erie, Pa. 1949 ASME Semi-Annual Meeting paper No. **49—SA-7** (in type; to be published in Trans. ASME).

The motor-generator type of locomotive permits the application of the direct-current series-wound traction motor, with its highly desirable characteristics, to electrifications deriving their power from a single-phase alternating-current trolley. This is of particular benefit in the operation of heavy-drag freight trains on mountain grades. Nearly 30 years of design and operating experience have gone into the development of this type of locomotive. The latest examples are the units recently placed in service on the electrified sections of the Great Northern and Virginian Railways. Noteworthy features in the design, construction, and operation of these units are discussed.

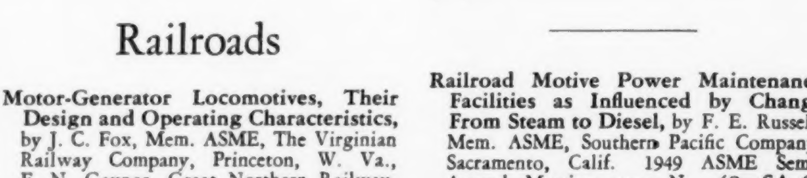
In addition to relative simplicity of construction, the series-wound motor has the characteristic ability of producing, without appreciable damage to itself, high initial torques without accompanying armature rotation—a characteristic which finds practical utilization when the motor is used in a locomotive that is required to "lay up" against a heavy train in the effort of getting the train under way.

The drop in speed and rapid increase in torque of the series motor as its loading is increased, with the accompanying tendency to maintain, to a certain extent, a relatively constant load on the power source, make this type of motor well suited for traction purposes.

The alternating-current synchronous-motor, direct-current generator set, in combination with a suitable static transformer of the conventional alternating-current type, seems to be the most practical means of energy conversion for locomotive use, where direct-current series-wound traction motors are employed.

Railroad Motive Power Maintenance Facilities as Influenced by Change From Steam to Diesel, by F. E. Russell, Mem. ASME, Southern Pacific Company, Sacramento, Calif. 1949 ASME Semi-Annual Meeting paper No. **49—SA-42** (mimeographed).

The change from steam to Diesel-electric motive power which is taking place throughout the country is having a far-reaching effect on maintenance facilities. The two types of power are substantially different in so far as inspection and maintenance requirements are concerned, and it is necessary that extensive changes in facilities be made. Some of the existing steam-locomotive facilities will be abandoned, others will be remodeled, and some new installations are required. This paper outlined the requirements for efficient Diesel-locomotive maintenance and repair, and describes facilities which are being provided to handle this work.



CROSS-SECTIONAL ELEVATION OF 5000-HP GREAT NORTHERN LOCOMOTIVE

A considerable expenditure of money is involved in providing these facilities, but they will pay for themselves in a short time by making possible efficient servicing and greater availability of the power. Quality of workmanship and morale of maintenance personnel are improved by establishment of modern facilities where shops and locomotives can be kept clean and orderly. The required facilities are in all cases a joint undertaking of the operating, mechanical, engineering, and stores departments, and close co-operation between these departments is necessary in planning the size and type of facilities to be provided at various locations.

Coal-Handling Systems for Locomotives, Past, Present, and Future, by J. J. Kane, Standard Stoker Company, Inc., Erie, Pa. 1949 ASME Fall Meeting paper No. **49—F-15** (mimeographed).

The history of coal-handling systems for locomotives is traced from as far back as 1850 to the present. The type B stoker, and BK and HT type stokers are described. Present-day systems which are discussed include the dual-level tender trough and the automatic stoker.

As to the future, the development of a coal-fired locomotive to equal or better the operating performance, availability, and operating cost of the present Diesel locomotive is fast becoming a reality. The need for development of the coal-fired locomotive is very evident because of the possible future scarcity of oil, the paper states. The low cost, availability, the great power potential, and the vast supply of coal make it the ideal and economical railroad fuel.

Although three research and development programs are now under way, only two basic locomotive designs are being considered—the gas-turbine and the steam-turbine, both combined with an electric drive.

The gas-turbine power unit is being approached from two angles: (1) Using coal to produce gas, which in turn is burned for the turbine energy supply; (2) burning pulverized coal under pressure in new radical combustors with direct air supply to furnish energy for the gas turbine.

In the steam-turbine program the use of the water-tube boiler, pressure furnace, and complete combustion controls are features involved in present designs.

With regard to the fuel-handling system for these locomotives, the first consideration is the extremely low hourly fuel demand. The proposed steam-turboelectric will use approximately 6500 lb of coal per hr at the maximum operating condition, while the gas-turbine units will demand between 4000 and 4500 lb per hr at their highest operating rate. These low fuel rates combined with coal conditioning, pulverization, evenness of supply and feed, and the pressurized system of combustion set forth new and challenging demands on the coal-handling systems.

Machine Design

Experimental Aids in Engineering Design Analysis, by Walter W. Soroka, University of California, Berkeley, Calif. 1949 ASME Semi-Annual Meeting paper No. **49—SA-24** (mimeographed).

In this paper analog computers and simulators for the experimental analysis of complex problems in engineering design are classified in accordance with their fields of application. Certain partial differential equations occurring in elasticity, heat flow, and fluid flow (ideal flow, percolation, lubrication) are readily solved by soap films, electrically conducting slabs, electrolytic tanks, and resistance networks. Certain ordinary differential equations occurring in dynamics (vibration, impact, automatic control) are readily solved by means of electric circuits containing lumped circuit elements.

For the more complex ordinary differential equations, particularly when nonlinear parameters are involved, the mechanical and electronic differential analyzers make solutions practical.

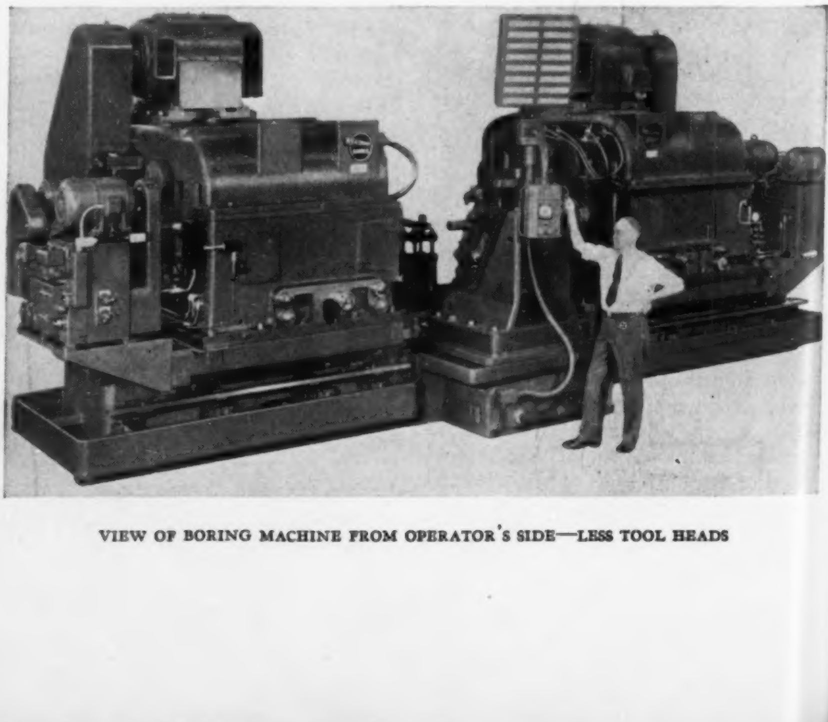
Algebraic equations of high degree frequently occur in engineering-design problems. The time-consuming drudgery of solving them is obviated by means of electrical and mechanical root-finding machines.

Development of a Special Four-Spindle Boring Machine for Finishing Traction-Motor Magnet Frames, by G. A. Baltus, General Electric Company, Erie, Pa., and D. H. Garmoe, W. F. & John Barnes Company, Rockford, Ill. 1949 ASME Fall Meeting paper No. **49—F-3** (mimeographed).

The accurate and economical machining of traction-motor magnet-frame castings involves a number of manufacturing problems. This paper outlines the design of a machine specially adapted for the job. Factors taken into consideration in its development are the accuracy and alignment of bores and the squareness of faces; flexibility for use on a range of model sizes; adaptability to carboloy tooling; special fixturing; provision for automatic cycling; and design for lower unit cost.

The machine as designed and built weighs 74 tons. The base is of three-piece construction, bolted and doweled together, and measuring approximately 28 × 10 ft. Each of the two machine heads is mounted on two ways 10 in. wide and 20 in. apart with tapered gibs on the outer edge of both ways. One way is backed up by a shoulder on the saddle making a long narrow guide to insure accurate alignment. These ways are covered by a roller curtain to prevent chips and dirt from injuring their surface. Precise vertical alignment of the spindles in the two heads is obtained by a matching taper of $^3/_{16}$ in. per ft between one head and its saddle, so that $^1/_{16}$ in. horizontal adjustment produces 0.001 in. vertical movement.

A 10-in-diam hydraulic cylinder located between the ways is used for both the feed and rapid traverse movements. The range of feed rate is from $^3/_8$ to 2 in. per min and the rapid traverse rate is 45 in. per min. One head has a maximum



VIEW OF BORING MACHINE FROM OPERATOR'S SIDE—LESS TOOL HEADS

travel of 36 in., the other a travel of 24 in. A pressure switch is incorporated in each cylinder to prevent damage by excessive pressure.

Each head is driven by a 50-hp variable-speed (450/1800 rpm) direct-current motor giving a high-speed range, through the gear reduction of 40 to 160 rpm on the axle-boring spindle, and 20 to 80 rpm on the head-boring spindle. The corresponding low-speed range is 6 to 24 rpm and 3 to 12 rpm, respectively.

In the control pendant there are buttons connected to a motorized rheostat for each drive motor, allowing the spindle speed of either head to be increased or decreased. A lighted panel directly above the pendant and swinging with it indicates which phase of the cycle is in operation.

A coolant system is available but its use has not been found necessary to date. An air jet in each axle bore prevents the chips lodging in the keyways and damaging the carboloy tools.

The machine is equipped with forced-feed lubrication. A special feature is a pressure switch which prevents operation of the machine if it is not being properly lubricated. For instance, the heads will not go into feed or traverse unless the ways are properly lubricated.

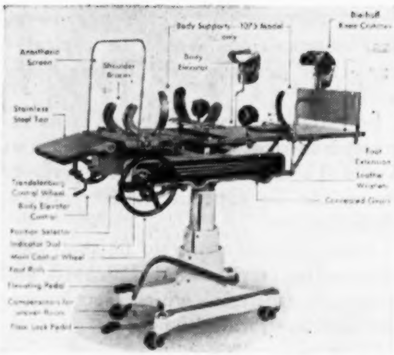
Engineering Aspects of the Surgical Operating Table, by R. L. Jewell, American Sterilizer Company, Erie, Pa. 1949 ASME Fall Meeting paper No. **49—F-4** (mimeographed).

Surgical tables may be divided into several classes, such as obstetrical, urological, fracture, and general surgery. This paper pertains to the functional and mechanical developments of the general surgical operating tables, and in particular to the type referred to as universal head-end control table.

The requirements for surgical posturing of the patient and the manner in which the problem is met are briefly described.

The complete table without patient weighs approximately 400 lb and is mounted on a base of sufficient spread to assure stability. Four heavy-duty ball-bearing swivel casters provide for maximum ease of movement. When in use the table is immobilized through four compensating floor locks, actuated by a single pedal.

The superstructure is mounted on the base through two telescoping splined columns. Four steel keys for each column are babbitted in place and are adjustable to reduce play to a minimum and assure smooth operation.



OPERATING TABLE WITH STANDARD ACCESSORIES

A single-action hydraulic pump having a telescopic lifting plunger concealed within the pedestal and sliding columns elevates the table top through a range of 15 in. Multiple thrusts of the single pump pedal elevates the table top, and continued downward pressure opens a release valve for lowering.

To provide complete articulation and flexibility the table top is divided into back, seat, and leg sections hinged together and linked to the control mechanism so that they may be adjusted separately or in combination through the complete range of required surgical postures. Adjustable and removable foot extension section and headrest are provided.

Adjustment of the table-top sections in relation to each other and lateral angulation (20 deg to either side) of entire superstructure are obtained through means of a selective gear shift and operating wheel located on the right side of table, while the wheel located on the left side of the table controls longitudinal angulation (50 deg in either direction) of the entire superstructure.

An auxiliary body elevator, operated through a small crank and self-locking gears, is provided between the back and seat sections.

It should be noted that all of the controls are at the head-end of the table within easy reach of the anesthetist.

Some Engineering Problems Associated With Metals in Elevated-Temperature Service, by F. G. Sefing, The International Nickel Company, Inc., New York, N. Y. 1949 ASME Fall Meeting paper No. **49—F-14** (mimeographed).

It is the intention of this paper to draw attention to some of the high-temperature effects up to 1000 F. Special consideration is given to the importance of associating failures and changes in properties under these conditions from those prevailing at room temperatures. The effects of elevated temperature service up to 1000 F upon the properties of metals can be found tabulated in handbooks and the current trade literature.

Thermal stresses resulting from cycling of service temperatures or occasional heating and cooling are shown to be of threatening proportions. In addition, these thermal stresses often tend to concentrate to certain areas in the design, thus exceeding the fatigue limit or, indeed, the tensile strength of the metal.

Changes in metal structure with time at temperatures up to 1000 F can and do occur. The use of specially designed alloys to prevent these metallurgical changes is shown to be the sensible approach to such problems. Wear resistance in cylinders and other metal-to-metal wear service is reviewed as affected by elevated temperatures. Likewise, abrasive wear resistance is explained to change materially with elevated temperatures because of the many factors other than hardness involved.

Internal stresses of equipment resulting from fabrication can be released at elevated temperatures, resulting in distortion and/or rupture. The importance of stress-relief annealing to permit greater working stresses is reviewed, with examples.

Because elevated-temperature service involves metallurgical, design, and maintenance problems, the need for greater co-operation between the engineers in all of these fields is emphasized. Furthermore, because new metals and better metallurgical controls are constantly being developed, it is urged that specifications and engineering codes be reviewed constantly to take advantage of these improvements in metals and alloys

Wood Technology

Glue Spreaders—A Study in Design, by Thomas D. Perry, Fellow ASME, Moorestown, N. J. 1949 ASME Wood Industries Division Meeting paper No. **49—WDI-1** (mimeographed).

With some 400 hot presses in use, each capable of producing approximately 10,000 sq ft of plywood per working day, and having a total of 30,000 sq ft of single glue line, the problems of efficient and economical glue spreading assumes a new importance. At the rate of 50 lb of liquid-glue mixture spread on each 1000 sq ft of joint (a reasonable optimum), and a 50 per cent solids content, this requires some 1500 lb of mixture per stress per day, or 750 lb of solids of which approximately 450 lb is resin and 300 lb is extender. Carried out to an annual basis of 250 working

days, on 400 hot presses, the yearly consumption of hot-press resin adhesives appears to be approximately: 400 × 250 × 450 = 45,000,000 lb, or 22,500 tons. This does not include the other conventional glues, casein, cassava, soybean, animal, etc., which have been more or less superseded by the resin adhesives. Nor does it include the resin adhesives used at room temperature, so that the total is probably considerably larger.

The only published figures for 1949, by the U. S. Tariff Commission, are as follows:

	Lb dry
Phenolic resin adhesives	20,700,000
Urea resin adhesives, including fillers	52,200,000
Total annual consumption, 1948	72,900,000

It is quite obvious that the equipment to spread the right amount of adhesive is of definite importance in such a highly competitive product as plywood, especially since the resin adhesives are priced in the range of 18 cents to 25 cents per lb, dry base.

This study is particularly directed toward the shape and size of grooves in the spreader rolls, which transfer the ridges of liquid glue to the wood. Smooth rollers have been little used in woodworking, since the method of applying parallel ridges of glue provides an excellent opportunity to judge, visually, how much glue is being transferred and with what degree of uniformity.

Two Slants on Postwar Wood Finishing—Current Practice, by Paul S. Kennedy, Mem. ASME; **Suggested Method for Predicting Check Resistance of Lacquer Films,** by W. T. Smith, Interchemical Corporation, Newark, N. J. 1949 ASME Wood Industries Division paper No. **49—WDI-2** (mimeographed).

PART I CURRENT PRACTICE

Fillers have come into use, employing various synthetic vehicles—as contrasted with the long-accepted linseed-oil vehicle—and drying time has been shortened to periods of an hour and is also giving better clarity. The ultimate in this direction has been achieved with the stain-filler combinations, employing fast to light dyes.

From the standpoint of speed, saving of floor space, and fast and easy touch-up and repair, lacquer is the ideal finish for wood. But it does have the shortcoming of what might be termed low solids or film thickness.

A resultant trend has been to secure the desired film thickness by means of synthetic coatings—of which alkyd-urea base compositions would be typical—and these are currently finding some usage.

Investigation by finishing manufacturers is currently under way with various kinds of synthetics, and further developments can be expected with synthetic clear coatings.

Many of the synthetic finishes have outstanding resistance to alcohol and many other materials which affect lacquer and ordinary varnish films.

PART II CHECK RESISTANCE OF LACQUER

The tendency of clear lacquer-type furniture finishes to fail by severe checking, especially under exposure to wide and abrupt changes in temperature, has long resisted accurate and significant laboratory prediction and control. In an effort to perform control tests of the film-forming media, carefully controlled and presumably representative wood panels are prepared, aged for a period of up to two weeks, and then subjected to a systematic cycle of temperature extremes in an effort to establish the limits of check resistance of the finishing system in question.

Distinct stresses are set up in a cellulosic film in the process of setting. This effect is influenced by the nature of the incorporated resin as pertains to solvent release and basic molecular arrangement, the viscosity of the cellulose, and the thickness of the film. The actual moisture content of the film itself, especially in the presence of alkyd resins and/or vegetable oils, is a directly pertinent influence on tendencies to check at low temperatures. It is indicated that mechanical failures such as checking and cracking are rupture phenomena, and the result of external and/or internal forces. These phenomena are influenced by nonuniformity of the film or the substratum which leads to local stresses.

Checking of lacquer films is due to the following factors: The deforming force, nonuniformity of the film, and local stresses exceeding the film strength.

Deforming forces may be caused by changes in the substrate. Moreover, the film may undergo contraction on aging, and this may lead to stresses and strains in the film which are dependent upon the mechanical properties of the coating. The solvent will evaporate from the lower layers much more slowly than from the outer layers. Consequently the stresses in the outer layers will grow more rapidly than in the lower layers, reach a maximum value in the surface layer, and decrease in the direction of the substrate. However, as the drying and aging proceed, the distribution of stresses will become more uniform. Shrinkage takes place at a measurable rate for a period of thirty days or more, and, together with progressive development and relief of stresses, is not confined to a short time interval. When films dry and age, shrinkage occurs which results in deformation and causes stresses. The theoretical examination of the mechanical processes taking place during film formation indicates that stresses occur even while the film dries.

ASME Transactions for September, 1949

THE September, 1949, issue of the Transactions of the ASME, which is the *Journal of Applied Mechanics*, contains the following:

Primary Creep in the Design of Internal-Pressure Vessels, by L. F. Coffin, Jr., P. R. Shepler, and G. S. Cherniak (48—PET-18)

Analysis of a Single Stiffener on an Infinite Sheet, by S. U. Benscoter (49—APM-13)

Application of Electric-Analog Computers to Heat-Transfer and Fluid-Flow Problems, by G. D. McCann, Jr., and C. H. Wilts (48—HTF-1)

Compliance of Elastic Bodies in Contact, by R. D. Mindlin (48—APM-24)

Fatigue Under Combined Pulsating Stresses, by H. Majors, Jr., B. D. Mills, Jr., and C. W. MacGregor (48—A-7)

The Dynamics of Cavitation Bubbles, by M. S. Plesset (48—A-107)

Energy Method for Determining Dynamic Characteristics of Mechanisms, by B. E. Quinn (48—A-18)

Press-Forging Thin Sections: Effect of Friction, Area, and Thickness on Pressures Required, by William Schroeder and D. A. Webster

General Features of Plastic-Elastic Problems as Exemplified by Some Particular Solutions, by Rodney Hill (48—A-13)

Bending of Rectangular Plates Subjected to a Uniformly Distributed Lateral Load and to Tensile or Compressive Forces in the Plane of the Plate, by H. D. Conway (48—A-12)

The Dynamic Response of a Simple Elastic System to Antisymmetric Forcing Functions Characteristic of Airplanes in Unsymmetric Landing Impact, by J. B. Woodson (48—A-16)

Discussion on Previously Published Papers by F. C. W. Olson; M. P. White; R. M. Drake, Jr.; F. Hymans; and J. D. Keller

Book Reviews

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Graduate Engineer Training

COMMENT BY CYRIL O. RHYS[1]

It would be difficult to improve upon Professor Hartman's specifications[2] for aids to the colleges in training future engineers. It is noted that drafting ability is (quite properly) high on this list.

The curious dislike of drafting work, which seems still to persist, is of very old standing, especially in this country. It does not exist (at any rate to anything like the same extent) abroad, which may account for the conclusion reached in the section of the paper, "U. S. Trained Designer Versus European." It is believed that this dislike may be traced to the extremely academic methods used in colleges in the teaching of descriptive geometry. The writer has taught this subject in an engineering college, and found it to be a most unpopular subject for this reason.

There is no doubt of the extreme importance of drafting ability in machine design, which has long been recognized. One of the greatest teachers of engineering (John Perry, M.E., D.Sc., F.R.S.) says in his Applied Mechanics ". . . . no study of books, and I may also say, no fitter's or turner's work that you may engage in, will make up for want of the experience which you would gain by actually drawing to scale a spur or bevel wheel, a bracket or pedestal with brasses, and a few other contrivances used in machinery." This book was written 50 years ago and was reprinted nine or ten times up to 1916.

Regarding the section of the paper on "Machine-Design Training," I also would quote Perry as follows:

". . . I was strongly tempted to take up the thorough consideration of one machine and call this the study of applied mechanics; and if I had a student with a particular interest in one machine this would be the very best way to put before him the study of applied mechanics. The method I have adopted in this book is to illustrate each principle by means of a machine in which that principle happens to be most important. The defect of the method arises from its causing the student to think that he knows all about a machine when he only knows the most important principle of applied mechanics which is illustrated by it. The cure for this "academic" training defect comes when a student is compelled to take a special interest in some one machine, and it is then, in practical work, that he really is learning applied mechanics."

The writer feels that Perry's thoughts on the subject are in line with the general trend of Professor Hartman's paper.

[1] Westfield, N. J. Mem. ASME.

[2] "Graduate Engineer in the Field of Design," by J. B. Hartman, MECHANICAL ENGINEERING, vol. 71, May, 1949, pp. 403–405.

COMMENT BY E. N. BALDWIN[3]

The timely report of the survey made by Professor Hartman indicates the interest of engineers in industry in the preparation of student engineers. The writer had the privilege of reading one of the letters received by Professor Hartman which showed clear thinking and deep concern for the training of the undergraduate. Information in this letter was backed up by a survey made in a large community where a group of men are studying this problem as an industry-wide project. The American Society of Engineering Education has a very active committee on "Relations With Industry," and the theme of its national June, 1949, meeting was "Partnership With Industry."

All this activity emphasizes the fact that industry is willing to give constructive assistance, and that the members of the teaching profession are seeking such assistance. Although there is no criticism of the work being done, there is the realization that improvements can be made. Therefore, it is recommended that the work of this survey and others be followed up by definite action on the part of this Society. There should be close co-operation between the colleges and industry to determine the basic contents of courses in mechanical engineering and the examinations required for professional status. A definite organization should be set up to influence and guide the policies in a general direction over a period of years for the entire nation. Other engineering professions have successfully inaugurated a program which has been of a mutual benefit both to the men of the profession and to the colleges. This is especially exemplified by the architects, who have controlled successfully the fundamentals which they consider an architect should know and still have been able to give freedom to creative thinking and originality.

Professor Hartman's report brings out clearly that basic information and training—requirements for the engineering student—are not up to standard. After 2 years on the campus and 25 years in industry, the writer is beginning to realize the problem that the engineering educator has to face in meeting the demands of the many specialized fields. The more one studies this problem, the more convinced he is that the underlying and basic subjects are of more importance to the engineering profession than the specialized fields. For example, machine-design courses, if conducted properly, can encourage initiative and originality and show clearly the relationship between materials, manufacturing processes, and functions of design. The knowledge the engineering student gained in mathematics, mechanics strength of materials, engineering shops, and test laboratories can be crystallized in the design courses. Such design courses should be basic to electrical, mechanical, industrial, aeronautical, and chemical engineering, and to such specialties as gas and steam turbines, heat transfer, boilers, tool design, electronics, and electrical-equipment design.

Although each engineer realizes that basic information is required, he finds that fundamentals are rather difficult to define. Opinions on basic requirements differ widely. It has been left to the colleges to determine the contents of their courses under the guidance of ECPD. Now is the time for a definite and concerted action on the part of the men of industry and members of this Society to direct the course of study of the future mechanical engineers through an active and progressive organization.

[3] George Westinghouse Professor, The Pennsylvania State College, State College, Pa. Mem. ASME.

COMMENT BY B. P. GRAVES[4]

This paper is a fine survey of industries' thoughts in preparing specifications for tomorrow's engineers. Under the heading, "The Type of Man Industry Seeks," the writer believes could be added creative ability and imagination, as both of these qualities are essential to a man entering into the field of machine designing.

This paper tells the same old story of a student being reluctant to enter into the drawing room for drafting training. It has always been the writer's thought that a student in choosing machine design necessarily must like drafting, because it is the only practical means of putting down his thoughts in a way that can be used by industry. The writer definitely feels if the student has enough of the characteristics that go to make up a good machine designer, industry cannot afford to leave him very long in the drafting room. The reluctance on the part of the young engineer to enter the drafting room is a serious problem and one that is very apt to retard his progress. If, in his college training, the student had more practical drafting-room practice, he would be in a better position to enter into the machine-design field.

Machine designing is a most fascinating profession. It is one which permits the working out of an idea and seeing it blossom and grow into something alive and of service to mankind. Because of this aspect, the Machine Design Division of the Society has set up a speakers' group, composed of practical men (who have come up through machine designing). These men go out among the various engineering schools and, in a series of talks, get this conception across to the student bodies. This has been in progress about a year and has proved most profitable both to the students and to the speakers.

It is believed that a course in machine designing can be streamlined to advantage, putting stress on the fundamentals of engineering, and co-ordinating the various courses, such as electrical, hydraulics, etc., summing it all up in a series of practical problems. The writer feels certain that industry would be most willing to furnish many of these problems which could be studied and presented to the student bodies, proving of immeasurable advantage to them.

One other item should be added to the specifications, namely, attention should be given to the training of a student so as to make him a good writer, as it is a very important qualification in the field of machine designing. Often a designer is called upon to express himself in writing on the various problems, upon which he may be working.

What the author says in regard to machine-design training is excellent, but the writer would like to add that the advanced course be built around the practical side, with the thought in mind of having the students put into practice, while in college, much of the theory being taught, in order that they may be in a better position to cope with the problems they are given when entering industry.

[4] Director of Design, Brown & Sharpe Manufacturing Company, Providence, R. I. Fellow ASME.

COMMENT BY E. C. KOERPER[5]

Professor Hartman's comprehensive survey makes good progress to the wider recognition of the responsibilities and requirements for success on the part of the designer. It is felt that the general conclusions are sound, although there are some definite advantages also in having some practical experience before doing postgraduate work.

The following thoughts are suggested for consideration:

The transition from "tracer to designer" is a process not well understood by personnel operating in the drafting and engineering departments, yet the gradual development of the designer and his increasing value are based on an orderly, although often slow, process. It is desirable that this be understood more clearly by student, teacher, and by industry. When warranted by ability and ambition, the end objectives of the designer might be either administrative work or highly specialized design. The emphasis on some of the basic qualifications for these two fields is quite divergent.

A designer's interests and abilities, as well as the job requirements, vary considerably. Early recognition should be given to the basic personal requirements for the particular job or series of jobs on which a man may start. For instance, the designer who has strong mathematical interests may do best on vibration research on a highly refined machine. He might be unsuccessful on a job in which emphasis is given to the actual operational requirements of the machine. Most individuals and jobs vary in their requirements and potentialities in this respect.

If a man does not reasonably match the developing job potentialities over a reasonable period of time, both he and his employer lose cumulative benefits

[5] Research and Engineering Laboratories—Administration, A. O. Smith Corporation, Milwaukee, Wis. Jun. ASME.

COMMENT BY C. HIGBIE YOUNG[6]

Professor Hartman has done a worth while job, and the results of his investigation are quite enlightening. The writer would emphasize particularly the desirability of summer work. No amount of formal study can be complete until it has been rounded out with practical experience. The sooner this practical experience can be obtained, the better for the student. The ideal method is to have the two occurring simultaneously There are, however, some pitfalls.

Foremost among items to be mentioned is to ask industry to be more liberal with the jobs in machine design which are made available. The writer's experience has shown about one job in the machine-design field to five or six in other fields. The students comment on this and seem to feel that lack of employment is indicated in that particular field

Sometimes it puts the boy on the spot The writer recalls a very sad experience where a young student spent two summers with one company in its design department. He started his senior year quite elated with his prospects for employment. During the winter, the company cut down its machine-design department, and he was out of a job Not only that, but the company hired one of his colleagues for an opening in other work, turning him down because he had become too specialized.

The continuation of this discussion leads into consideration of the reluctance on the part of young graduates to elect to enter the design field. Professor Hartman has indicated under "Drafting Ability," the most significant reason for this. Industry calls them draftsmen. If these same men go into testing they are called test engineers As suggested in the paper, a little more glamour to the work; a little more careful outlining of the duties, would tend to lessen somewhat the resistance on the part of the young engineer. Another real handicap is that the pay is not commensurate with similar jobs in other departments which at the same time are open to the graduate. There is no question but that the student-branch talks given by the Machine Design Division of the Society are helping in clearing up this situation.

The writer agrees heartily with the author's findings covering the treatment of the subject matter as included in the curriculum. It is gratifying to note that shop courses are being elevated to a

[6] Professor and Head of the Department of Machine Design, The Cooper Union. Mem. ASME.

higher educational level and the vocational emphasis being dropped. This is a step in the right direction, especially if it is supplemented by summer industrial employment.

The real difficulty lies in defining what is meant by fundamental subjects. What one man considers a fundamental, another classes as advanced work. One strong objection would be against the inclusion of "advanced dynamics," except on an elective level. It is agreed that all mechanical-engineering students should have some acquaintance with this subject, but, in general, it would only treat of the elementary problems and some idea of handling the solutions. There is not time enough in the curriculum of the present-day college courses on the baccalaureate level to cover every subject with any degree of completeness. However, where a student has elected the design field as his major subject matter, it would be well to give a more thorough treatment of this subject at the expense of some time now devoted to "heat power," provided the college is set up to handle such electives.

The work Professor Hartman has done is greatly appreciated, and it is believed that his findings will make a worth-while contribution to our study of this problem.

Author's Closure

The extent of the discussions, both written and oral, have indicated to the author of this paper that this is a subject of interest to both industry and educators.

One must agree with Mr. Rhys that if some drafting ability is essential in the graduate engineer, then we must reexamine present methods of presentation in the classroom and in early industrial contacts.

Along with Professor Baldwin, the author feels strongly that there is a need for close co-operation between industry and the teaching profession in order that each may appreciate the other's problems and requirements. This society, by sponsoring such co-operative efforts, can contribute a great deal to the curriculum planner in the college and those responsible for training in industry.

Mr. Graves always contributes comments of great value to discussions of this type. It is hoped that the activities of the speakers' group of the Machine Design Division will be continued and extended.

Mr. Koerper is correct in pointing out the advantages of practical experience before graduate work. Too often the student engineer has little basis upon which to make a decision in regard to fields of specialization.

Professor Young contributed an extremely pertinent paper at the 1948 Annual Meeting, entitled "What Can the Machine Design Field Expect From the Recent College Graduate?" It is unfortunate that both these papers could not be discussed at the same meeting.

If industry is disturbed by the reluctance of graduate engineers to enter the field of design, then certainly industry should be certain that the jobs are made to appear attractive in regard to salary and "glamour."

It is true that educators constantly discuss "fundamentals" but seldom define them. Discussions of problems in engineering education are seldom concluded, hence they provide a continuing challenge. The author proposes that those actively engaged in engineering education and training constantly examine their work in the light of this question. Is every effort being made to stimulate and encourage careful, systematic, analytical thinking?

J. B. Hartman.[7]

[7] Associate Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pa. Mem. ASME.

Electrical Controls in Thread-Grinder Design

Comment by Granger Davenport[8] and C. A. Poekel[9]

In general the recent paper by E. V. Flanders[10] is indicative of the close coordination between electrical and mechanical engineers in designing intricate precision machine tools.

The first reaction of the reader is that the author is attempting to defend the use of electrical controls. In a sense the term "electrical controls" is likely to be misinterpreted, because a machine, utilizing either hydraulic or pneumatic power devices, usually is controlled electrically, just as electric motors or solenoids are. In the case of hydraulics or pneumatics, an electric coil is usually energized, thereby causing a valve spool to move, which in turn completes or causes the completion of a hydraulic or pneumatic function.

In initiating a new design of a machine tool, the designer first must decide whether the machine is to be all mechanical (with the exception of the main motor drive), or a combination of mechanical, electrical, hydraulic, or pneumatic devices. Having once made the choice that the machine will contain devices other than mechanical alone, any machine that is to be semiautomatic or automatic is almost certain to utilize electrical controls. These electrical controls then become a necessary item, which in itself may or may not be the deciding factor that will determine whether a design is the best for the purpose.

The author rightly points out the flexibility of electrical equipment in permitting thread-grinding machines to be more or less custom-built according to the user's requirements. Nevertheless, this feature which is so advantageous from the manufacturer's standpoint, should not overshadow other important considerations such as original cost, power consumption, over-all cycle time, operational ease, and serviceability in a customer's plant.

If all of the factors mentioned are analyzed carefully to determine the most economical and practical solution, one might rightly challenge the use of five separate motors for the automatic-cycle machine described, in comparison to the use of hydraulic cylinders or other hydraulic devices, for at least a portion of the cycle.

[8] Assistant Chief Engineer, Gould & Eberhardt, Incorporated, Irvington, N. J. Mem. ASME.

[9] Development Engineer, Gould & Eberhardt, Incorporated.

[10] "Electrical Controls in Thread-Grinder Design," by E. V. Flanders, Mechanical Engineering, vol. 71, May, 1949, pp. 381–388.

Comment by Walter E. Addicks[11]

The author recommends that the machine designer give serious and favorable consideration to electrical control as the most desirable means of accomplishing the intended operation of the machine, in so far as automatic cycling and optional or variable features are concerned. He stresses flexibility and ease of experimentation or change as features almost exclusive with electrical control.

These features are indeed important to the machine designer, and they are likewise important to the user of the ultimate machine. To the user, easy adjustment of speed or timing, easy selection of sequence of operations, and the possibility of relatively simple addition of new features—these qualities may justify an investment that would not be justifiable if the machine were strictly single-purpose and incapable of change without the purchase

[11] District Manager, Cutler-Hammer, Inc., New York, N. Y.

of costly cams, valves, or other mechanical and hydraulic devices. Therefore, the interests of the designer and the user are closely related, and the user's reaction seems worthy of note.

As the author points out, electrical control in the abstract is another and most important tool available to the designer in perfection of his product. This electrical tool is not necessarily in competition with mechanical and hydraulic means of obtaining a desired result. There is a logical field of application for each of these means, and the best final design is achieved only when the mechanical and electrical engineers working together recognize the possibilities, advantages, and limitations of each. The thread grinder described in the paper illustrates admirably what can be done when intelligent use of all means is accomplished.

This point leads logically to mention of the two roles which electrical control may play in machine design. In the electrical industry the function of control is stated as, to start, stop, regulate, and protect. These functions appear in simple form in respect to the main drive of the machine and in varying degree of complication elsewhere. The present-day automatic machine involves, in addition to the main drive, one or more auxiliary applications of power either derived mechanically from the main motor or derived from separately energized electric motors or hydraulic systems. The term electrical control may include the use of standard or special electric motors for auxiliary power, but in its usual sense electrical control means supervision and functional regulation of applied power from any source. Recognition of these two roles is important if the mechanical engineer is to understand the electrical engineer's lack of concern over trends toward hydraulic operation, trends such as appeared about 15 years ago in machine tools, and as appear from time to time in specialized machines of all types. The electrical-control engineer has no enmity toward hydraulics since he always has open to him the field of supervisory control. Hence full co-operation of the electrical-control industry may always be expected in machine-design problems.

In pointing out the ease and low cost of experimentation when electrical control is used, the author states that many electrical devices seem cheaply constructed, yet are capable of dependable operation over long periods of time. This is a most important point, as many mechanical engineers are afraid to trust to light almost fragile relays and other parts the operation of costly mechanisms and tools driven by power which can be destructive if not controlled. While control devices are not uniform throughout the electrical industry, they are available from many sources in thoroughly dependable form. Many control devices of the best lineage may be described as flimsy in a mechanical sense, but examination will usually show that such flimsiness is the secret of long and dependable service.

The typical control device is magnetically or mechanically operated to give a quick, instantaneous change from closed-circuit to open-circuit position, or vice versa, innumerable times per hour, per day, per month. Such operation requires in design avoidance of friction, avoidance of wearing points and, most important, avoidance of mass as a contributor to self-destruction. Telephone devices, especially those employed in automatic dial systems, are notable for dependability, yet they are extremely light and almost repugnant to the machine designer. Control devices commonly applied to machine tools and other automatic machines frequently must be equally light if they are to give long life and sure response to the actuating impulse.

This feature of light low-cost design contributes also to one of the principal attractions of electrical control—easy and inexpensive maintenance. The user of an automatic electrically controlled machine easily can afford to keep on hand for replacement as needed, contacts, magnet coils, selector switches, and the like, and even complete relays or limit switches. Reasonable protection from dust, dirt, oil, and other hazards, plus easy and inexpensive replacement of worn parts as required will give to electrical control equipment the long and dependable operation which is nowadays so prominent a characteristic of the machine to which it is applied.

The case for electrical control of automatic machines can fairly be allowed to rest on the fine record it has achieved throughout industry in serving such machines as the automatic thread grinder.

AUTHOR'S CLOSURE

The author wishes to express his appreciation of the fine discussions presented by Mr. Davenport and Mr. Poekel.

If there seemed to be a tendency on the author's part to "defend" electrical controls, it was unintended. The decision to use these controls was made after due consideration had been given to mechanical, hydraulic, and pneumatic devices. When our machines were first introduced we did meet with some resistance as electrical devices were not as well understood at that time as they are today.

Certain types of grinders we now build, use both hydraulic and pneumatic equipment, we believe for good reason.

We suggest a careful reading of the second, third, and fourth paragraphs of Mr. Addick's paper. In our opinion he has clearly stated, there, the place of electrical controls in machine design and their relationship to mechanical and hydraulic devices.

E. V. FLANDERS.[12]

[12] Chief Engineer, Thread Grinder Division, Jones & Lamson Machine Company, Springfield, Vt.

ASME BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, ASME, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the Cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is submitted to the Board on Codes and Standards, as authorized by the Council of The American Society of Mechanical Engineers, for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of August 12, 1949, and approved by the Council under the date of August 31, 1949.

CASE No. 1102

(Interpretation of Par. P-301)

Inquiry: Where only one boiler fur-

nishes steam to one turbine or other prime mover is it necessary to have a stop valve, other than the throttle valve, between the boiler and the prime mover?

Reply: It is the opinion of the Boiler Code Committee that the intent of the Code will be met if in the case of a single boiler and prime mover installation, the throttle valve of the prime mover is considered as the required stop valve, provided it is equipped with an indicator showing whether it is open or closed and provided it is suitable to withstand the required hydrostatic pressure test of the boiler.

Case No. 1103

(Special Ruling)

Inquiry: Is it permissible under the requirements of Section I and Section VIII to use Grade WC6 of ASTM Specification A217-47T. If so, what stresses may be used?

Reply: It is the opinion of the Committee that Grade WC6 may be used in the construction of power boilers under the requirements of Section I of the ASME Boiler Construction Code and Unfired Pressure Vessels under the requirements of Section VIII with the following stresses:

Temp deg F	*Psi*	*Temp deg F*	*Psi*
650	14,000	950	8,250
700	14,000	1000	5,850
750	14,000	1050	3,850
800	13,500	1100	2,200
850	12,000	1150	1,400
900	10,300	1200	900

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published herewith with corresponding paragraph numbers to identify their location in the various sections of the Code and are submitted for criticism and approval from any one interested therein.

It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

Par. P-301: Add the following sentence at the end of the first paragraph

IN THE CASE OF A SINGLE BOILER AND PRIME MOVER INSTALLATION, THE THROTTLE VALVE OF THE PRIME MOVER MAY BE CONSIDERED AS THE REQUIRED STOP VALVE, PROVIDING IT IS EQUIPPED WITH AN INDICATOR SHOWING WHETHER IT IS OPEN OR CLOSED AND PROVIDED IT IS SUITABLE TO WITHSTAND THE REQUIRED HYDROSTATIC PRESSURE TEST OF THE BOILER.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Partners in Production

Partners in Production: A Basis for Labor-Management Understanding. By the Labor Committee assisted by O. Nichols. The Twentieth Century Fund, New York, N. Y., 1949. Cloth, 5 × 7¾ in., ix and 149 pp., $1.50.

Reviewed by J. A. Willard[1]

THIS is the sixth in a series of twentieth century reports on labor-management relations published during the last thirteen years. It is written on a plane substantially higher than exists in the average labor-management dispute, but perhaps that is the only sound basis for real progress in labor relations in the future.

The Committee writing the report sees the solution of labor-management problems as part of the wider problem that confronts the world, between abundance and peace or poverty and war. They begin with the reminder that the organization of labor is a permanent part of our national life and collective bargaining has become the habit of the land. They feel we are going through a "difficult but promising period of transition from conflict to co-operation."

One of the best pieces of evidence they offer to support this contention is the fact that collective bargaining really does work. Strikes, even when they occur, lack the bitterness of the past, and Marxism has failed to gain a real hold among our workers. Labor is committed to the support of capitalism, though it has to be recognized that in general workers feel a need of reaching their ends through unions.

A substantial portion of the book is given over to a discussion of the goals and attitudes of labor. Despite the fact that strikes and labor-management negotiations usually center around the matter of wages, it is evident that the amount of money earned is not the first concern of workers. They crave job security, for one thing, and they feel unions play an important part in helping them to win this.

Although not brought out in the report the intensification of this desire for security dates back some twenty-five years, when the balance of our economy changed from agriculture to manufacturing. Under an agricultural economy man knew that four years out of five the weather would be favorable to a good living and that a year of disaster would usually be righted the next crop season. With the shift to a manufacturing economy there was no such certainty of relief from distress—a point proved to workers by the depression which started in the fall of 1929 and was not halted for several years.

In their search for security labor has sought to get government on its side through such measures as the Wagner Act, Social Security, etc. Spreading the work, the principle of seniority, the annual wage—these are other devices by which labor tries to protect itself.

All these facts are well known and this part of the book is more in the nature of a review. It is in the section where the workers' feelings of insecurity are ascribed to social causes that the study becomes really penetrating. Here it is contended that industrialization itself is largely responsible, although in

[1] Partner, Bigelow, Kent, Willard and Company, Boston, Mass., and New York, N. Y. Fellow ASME.

our opinion the causes are economic, having their origin in the shift to a manufacturing economy. In any case man has retaliated, now with fascism, now with communism.

The areas in which management's views clash with those of labor are gone into. For example, management feels that labor places too much emphasis on security, that in the capitalist system every one takes risks, high and low alike. Strict seniority irks management and sometimes is not good for labor either. At the same time management recognizes the desirability of a satisfied work force.

Management is trying to find the answer to the big question—what makes a worker productive? Management is also active in resisting the encroachment of the unions into the field of management responsibility.

The real value of the book lies in its proposals for turning conflict into understanding. The Committee feels that disputes over seniority can be ironed out and that a jointly responsible attitude toward the collective-bargaining contract can be attained. What the report boils down to is a plea for management and labor to learn to live together, to take steps to dispel suspicion and create confidence; a plea for the company to keep hands off the union and the union to quit taking side swipes at management.

Apparently one of the toughest problems is to convince the workers that the company is not getting the lion's share of the profits. Another important goal would seem to be to imbue labor with the idea that in reality they are working for themselves.

Running through this book are frequent references to the larger conflict of which the labor-management conflict is a part. There are reminders that people's unsatisfied yearning for security could lead them to dictatorships. All this gives the work considerable significance.

It is the individual worker that is put under the microscope in this study. What makes him tick? The conclusion is not a startling one. He wants a sense of usefulness and meaning in his job. He wants security in employment and a chance to get ahead, and he wants his work and his life to be surrounded with a little human dignity.

With the exception of the first few pages the book is beautifully written and well worth reading and holding in the mind for checking the future.

Fuel Economy Conference Transactions

TRANSACTIONS OF THE FUEL ECONOMY CONFERENCE, THE HAGUE, 1947. Three volumes. Volume 1, Introductory matter and "Fuel Economy Since 1939"; Volume 2, Section A, Production—General, Section B, Distribution—Liquid and Gaseous Fuels. Volume 3, Section C, Utilization—General. (In English, French, and German Languages.) Percy Lund, Humphries and Co., Ltd., London, England, 1948. Vol. 1, Cloth, 6 × 9½ in., tables, 8 figs., lvvii and 335 pp. Vol. 2, Cloth, 6 × 9½ in., illus., figs., charts, tables, maps, flow diagrams, 339 to 981 pp. Vol. 3, Cloth, 6 × 9½ in., tables, figs., illus., charts, maps, Subject Index, pp. 1447–1706, Name Index, pp. 1707–1716, vii and 983 to 1716 pp., £10 per set (approximately $40.33).

REVIEWED BY ELMER R. KAISER[2]

THE FUEL Economy Conference held at The Hague in September, 1947, was the first postwar Sectional Meeting of the World Power Conference. Its purpose was to review the progress and accomplishments in the production, distribution, and utilization of fuels and energy generally from 1939 to 1947 inclusive. Fifteen nations contributed a total of 77 papers and reports, of which 54 were in English and 23 in French, the two official languages. Of the latter papers, many are either published in both languages or are at least summarized in English. Each section ends with a well-written general report summarizing the papers, followed by discussions.

Anyone interested in the technical progress in fuels and energy, in the quantities produced and how they were used, and in how the countries met their wartime fuel problems, will find these volumes very interesting. In volume 1 are included the Reports by National Committees on Fuel Economy since 1939 for Algeria, Argentina, Australia, Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Germany (Allied Control Comm.), Great Britain, Hungary, Ireland, the Netherlands, Norway, Portugal, Sweden, Switzerland, and United States. The reports include statistics on coal, oil, gas, and electricity, and résumés of technical developments, new constructions, and studies.

These reports provide the statistics for the war years and recount the growth in fuel production, the restrictions in consumption, and the substitutions in fuels during the period. Drastic changes were forced on some countries; for example, Argentina's fuel imports were cut off with the result that 3,000,000 metric tons of domestic grain were burned per year for fuel and her railroads were operated on wood. The lower grades of coal came into wider usage with the result that technical progress was directed toward better coal preparation and toward methods for using higher-ash coals.

Volume 2 includes numerous papers on fuel and energy production and distribution. The British, French, and Canadian reserves of coal and their development are reviewed. The British study was necessary to compensate the owners when the mines were nationalized and to project coal production for 100 years. The recent Canadian survey reduced by 25 per cent the reserves estimated earlier.

Six papers on the production of solid fuels include mechanization at the mines, coal cleaning, and briquetting. The room-and-pillar method of coal mining in the U.S.A., with inherent losses of some pillars, was shown to be not adaptable to European use. In Europe the average depth is three or four times the average depth in U.S.A., necessitating larger pillars and increased losses. The coal resources in Europe are so limited that the loss of such coal must be taken seriously into consideration. Furthermore, spontaneous combustion of coal left in the mine would be so serious that a system by which coal is left in such a position that air can reach it will be out of the question.

The section on liquid-fuel production includes production of aviation fuel and shale oil, liquid fuels from bituminous sands, fuel oils, plant tissue, vegetable-oil cracking in China, and low-temperature carbonization.

Gas production in England is based on five main types of plants, in which half the gas is made from coal in continuous vertical retorts and one fourth in horizontal retorts, and the balance by other methods. Greater economy is possible by the use of high-temperature insulation of the ovens and by modern techniques of steam generation at higher pressures.

The dry cooling of coke has largely superseded quenching with water in Switzerland. Heat recovery and quality of coke are improved.

In the Netherlands it has been decided to use coke-oven gas for public and industrial heating and to use coke as the raw material for the future extension of the chemical industry. The coke-oven gas is apportioned to the public supply, while the coke is gasified to provide synthesis materials for the chemical industry.

The utilization of low-grade Soviet coals, anthracite culm, and peats is reviewed in considerable detail. Designs of boiler furnaces and pulverized-fuel equipment are shown and described with considerable national pride.

[2] Assistant Director of Research, Bituminous Coal Research, Inc., Columbus, Ohio. Mem. ASME.

Volume 3 on general utilization of fuels and energy is a collection of miscellaneous papers and a comprehensive subject index for the three volumes. Only a portion of the subjects can be mentioned here.

The cyclone burner and the spreader stoker, both American developments, have shown outstanding ability to use the lower-grade coals. The former is outstanding in the recovery of more than 80 per cent of the ash in the coal as molten slag, while the latter forms a minimum of clinker. The recovery of heat for steam raising from wet wood refuse and spent alkaline liquors from the paper industry is economical here under present conditions. Brown coal of 50 per cent moisture is being burned successfully in Australia with spreader stokers and single-retort underfeed stokers.

Electronic control of boiler furnaces with chain-grate stokers is being tried in Russia. Radiation from the furnace passes through an iris diaphragm to the detecting device. The opening of the iris is varied by steam pressure. Thus the steam pressure and the grate temperature, acting upon the detecting device, combine to control the fuel feed.

New data on heat transfer by convection and radiation in heating by gas were reported by English investigators. The British have also reported on the origin and formation of sulphates, phosphates, and alkali salt deposits on boiler tubes. Such deposits directly on the metal of steam-generator surfaces are less obvious than fly ash and slag, but may cause more damage by corrosion.

The increased price of fuel has emphasized the need for recovery of heat from hot water, steam, and waste products. For example, laundries can recover heat for heating clean water from hot contaminated water on its way to waste. Breweries could save 4 to 5 lb of coal per barrel of beer by heating water for washing and cleaning in a simple heat exchanger using vapors from wort boiling.

Drying of industrial raw materials and agricultural products by direct contact with furnace gases is under development in the USSR. A decrease in fuel consumption and a reduction in metal temperature in the drier were made possible by using the flue gases. Among the products dried were paper, fabric, hay, tea leaves, lumber, wood pulp, toothpowder, ammonium nitrate, and flax. Fuels used were anthracite, bituminous coal, oil, wood, husks, and gas.

District heating with exhaust steam from electric generating plants has won favor in New York City and is proposed in Holland for the reconstruction of Rotterdam. The fuel economy is attractive, but large investments are, of course, required in the steam mains. Eleven cities and towns in Denmark have district heating. A new combined power-heat plant has been planned for Copenhagen. Hot-water distribution is preferred for house heating. Even more ideal, the electric warming of buildings is practiced to some extent in Norway, where coal is high priced but water power is plentiful.

The section on use of energy for transport purposes describes the advances made in France and Italy to use gas turbines and higher-pressure steam turbines in ships. Electric railroad locomotives and Diesel traction are emphasized for France. The gas turbine is expected to succeed in competition with the Diesel because the fuel is cheaper. In the meantime, Sweden is electrifying its state railways.

In retrospect, the Transactions highlight so many developments in fuel that it is doubtful that anyone will feel any important aspect has been overlooked. Unless fuel prices decline in relation to other commodities, the trend toward greater fuel economy will continue. In any event, the increased utilization of low-grade fuels seems assured.

Reissner Anniversary Volume

REISSNER ANNIVERSARY VOLUME: Contributions to Applied Mechanics. Edited by the staff of the department of aeronautical engineering and applied mechanics of the Polytechnic Institute of Brooklyn, N. Y. J. W. Edwards, Ann Arbor, Mich., 1949. Cloth, 6 × 9¼ in., figs., illus., viii and 493 pp., $6.50.

REVIEWED BY J. N. GOODIER[3]

THE custom of celebrating the completion of a long span of significant work by a distinguished scientist is again observed in the publication of this book, dedicated to Hans J. Reissner on the occasion of his seventy-fifth birthday, January 18, 1949. A biographical introduction by R. P. Harrington, N. J. Hoff, and Paul Torda describes Dr. Reissner's activities in engineering and engineering science; civil-engineering studies in Berlin; experience in the United States and Germany; the development of aeronautics at Aachen, which included the designing and flying of airplanes in 1909 to 1913; a professorship at Berlin; design of the first controllable-pitch propellers; aircraft structural analysis; and excursions into physics. In the United States his tenure of professorships at the Illinois Institute of Technology and the Polytechnic Institute of Brooklyn has been distinguished by contributions to these and many other aspects of solid and fluid mechanics and their applications.

The thirty-two scientific and technical papers, contributed to the volume by friends, colleagues, and research students, cover, like Dr. Reissner's own interests, a very broad range of subjects. They form indeed an interesting partial survey of the great variety of engineering problems in which progress is furthered by the analytical and experimental techniques of applied mechanics. No more than an indication of the topics they deal with can be included in this review. More adequate accounts of most of these papers have appeared, or will, in *Applied Mechanics Reviews*.

In the group on aerodynamics, S. Bergman shows how tables may be constructed to reduce the difficulties of completing compressible-flow patterns by the hodograph method. W. Tollmien reconstructs the hodograph method from relations between co-ordinates and velocity without interposition of potential or stream functions. This is particularly advantageous in the consideration of singularities in the flow. R. P. Harrington and P. A. Libby determine what happens to a simple laminar frictionless incompressible flow along a plane boundary when a cylinder is placed in it, creating another two-dimensional flow. H. G. Lew takes account of compressibility in a preliminary study of the stabilizing effect of homogeneous suction on the boundary layer in flow over a porous surface. D. P. Riabouchinsky extends to two dimensions the analogy between one-dimensional gas flow and hydraulic channel flow, where the hydraulic jump is analogous to the shock wave. Photographs of corresponding flows are given, and the analogy between air and water flows although imperfect is regarded as useful for qualitative purposes.

In dynamics, M. Goland examines the conventional methods of analyzing the stability of aircraft and finds, by making exact analyses for two typical craft, that significant overestimation of stability can result from the customary replacement of the correct unsteady air forces by their "pseudo-static" equivalents. A contribution by P. Lieber and M. E. Hamilton explains a method for predicting the motions of a wing due to three-point landing impact.[4] R. Olden-

[3] Professor of Mechanics, Stanford University, Stanford University, Calif. Mem. ASME.

[4] *Applied Mechanics Reviews*, vol. 2, 1949, p. 124.

burger derives differential equations for a hydraulic transmission device designed to maintain a constant speed of the follower in spite of speed fluctuations of the driver, and solves an example for sudden constant acceleration of the driver. D. Williams contributes a very simple rule for determining approximately the higher natural frequencies and modes of nonuniform beams when the first one or two are known. S. W. Yuan and M. Morduchow discuss the stability of flapping and lagging oscillations of helicopter blades, the periodic coefficients of the differential equations being replaced by stepwise constants.

The third group of contributions is on elasticity and structures. A bar in a buckled structure may be under thrust or tension and subject to end moments which either restrain or encourage its bending. L. H. Donnell gives a chart from which the critical conditions can be readily found, and demonstrates its usefulness in some examples. K. O. Friedrichs outlines a method for investigating the local stresses at the edge of a plate in transverse bending, not accounted for by the ordinary theory. R. Gran Olsson shows how the differential equation of Rode for the deflection of the stiffening truss of a suspension bridge may be solved. The equation takes into account the horizontal movement of the cable and has nonconstant coefficients. E. Reissner broadens the theory of thin shells of revolution by using radial and axial rather than normal and tangential displacements, and indicates some solutions for shallow shells of both uniform and nonuniform thickness, the meridian curve being a parabola of the *n*th degree. A. Schleusner contributes an unproved solution of a problem of F. Kotter in the theory of earth pressures. G. Schnadel investigates the buckling strength of transversely stiffened ship decks, considering the elastic support afforded by the hull sides. J. J. Stoker outlines calculations made on the buckling of a circular plate due to insertion of a wedge in a radial slit, and of the stabilizing effect which such wedging can have on buckling due to edge compression.

Five related papers follow on concentrated load effects in reinforced monocoque cylinders. N. J. Hoff[5] summarizes the analysis of the very marked departures from simple beam behavior due to local irregularity in the neighborhood of the loads. V. L. Salerno shows by a cantilever example that these departures can extend as far as five or six diameters down the cylinder. H. Liebowitz analyzes the effects of the bending rigidity of the longitudinal stiffeners, B. A. Boley considers the eccentricity and the shearing and extensional deformations of the rings, and S. V. Nardo describes tests of nine such cylinders which indicate the degree of completeness now attained by this kind of analysis.

[5] Reviewed in *Applied Mechanics Reviews*, vol. 2, 1949, p. 106.

In electricity, R. M. Foster gives a study of a defined average of the entire set of driving-point impedances of a network, and R. Rüdenberg an analysis of the electron gun used as an illuminator for electron microscopes.

H. Geiringer, in the group of papers on mathematical methods, establishes some new convergence criteria for a process of perennial interest in engineering analysis—the iterative solution of a set of linear algebraic equations. R. Grammel describes a simple graphical representation of tensors alternative to the well-known representations by Mohr circles and ellipsoids. A. Weinstein shows that certain eigenvalue problems in partial differential equations may be paired in such a way that the eigenvalues for one problem are separated by those of the other, as the even numbers separate the odd ones.

In plasticity, R. von Mises contributes three remarks on the theory of ideal plastic flow. He gives solutions of torsion problems developed from the elastic "core," and of the thick tube under internal pressure, and gives a formulation in linear differential equations for the plane stress problem. A. Nadai considers the plastic distortion of thick cylinders due to pressure and longitudinal force, discussing finite strain, and the stability of the plastic equilibrium in relation to strain hardening. F. K. G. Odqvist analyzes the yielding of pressure vessels with dished ends in terms of a circular "plastic hinge" developing from the stress concentration at the junctions.

T. von Kármán obtains from elementary theory a possible explanation of the efficiencies obtained from simple thrust augmenters for jets. P. Torda gives an analysis in terms of one-dimensional unsteady gas flow of the behavior of reed valves in pulse-jet engines, carried out under the direction of Dr. Reissner himself.

Books Received in Library

GIORGIS RATIONALES MKS-MASSSYSTEM MIT DIMENSIONSKOHÄRENZ. By E. Bodea. Second edition. Verlag Birkhäuser, Basel, Switzerland, 1949. Paper, $6^1/_2 \times 9^1/_2$ in., 142 pp., tables, 24.50 Swiss fr. This book discusses the MKS system. It has four main parts: a review of the development of the physical and technical systems of measurement; an explanation of the properties and practical advantages of the Georgi system; a discussion of the theoretical principles of all dimension and unit systems; and an enlargement of the MKS system. It concludes with 17 tables of dimensions, units, and conversion factors.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by ASME Members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

INGENIEUR-TABELLEN, Zahlentafeln und Formeln für Studium und Praxis. By T. Ricken. Carl Hanser Verlag, Munich, Germany, 1949. Cardboard and half linen, $5^1/_2 \times 7^3/_4$ in., 292 pp., diagrams, tables, stiff cardboard, 9.50 DM; half linen, 11 DM. This comprehensive book of tables contains important numerical values for a wide range of engineering work. The use of the tables is facilitated by precise definitions and explanations. Arithmetical examples and technical formulas supplement the tables. There is a detailed subject index.

JAMES WATT AND THE HISTORY OF STEAM POWER. By I. B. Hart. Henry Schuman, New York, N. Y., 1949. Linen, $5^1/_2 \times 8^1/_2$ in., 250 pp., illus., diagrams, $4. Beginning with a short discussion of the main factors in human development, the author proceeds to a review of the social, economic, and scientific backgrounds to the life and times of James Watt, including the work of those who preceded him as pioneers of the steam engine. The remainder of the book provides a comprehensive picture of the career of this great 18th-century engineer and his contribution to the history of human progress.

MACRAE'S BLUE BOOK AND HENDRICK'S COMMERCIAL REGISTER, Fifty-sixth annual edition, 1949. MacRae's Blue Book Co., 18 E. Huron St., Chicago 11, Ill. Cloth, $8^1/_2 \times 11$ in., 3848 pp., diagrams, $15 U.S.A.; $20 foreign. This annual reference volume lists all manufacturers in the United States under a detailed product classification. The listing under each product is alphabetical by company. A complete alphabetical listing of company names, with capital ratings and local distributors, precedes the classified section. A 350-page trade-name index is included.

MANAGEMENT PLANNING AND CONTROL. By B. E. Goetz. McGraw-Hill Book Company, Inc., New York, N. Y., Toronto, Canada, London, England, 1949. Cloth, $6 \times 9^1/_4$ in., 294 pp., charts, tables, $3.75. This text develops a theory and practice of accounting from managerial needs for data to aid in solving problems of planning and controlling enterprise operations. The theory and technique presented are based on the use of incremental costs and revenues, and of opportunity costs. Practical examples of the application of the principles discussed are included, and a list of related reading material.

METALLURGISCHE VERARBEITUNG VON ALTMETALLEN UND RÜCKSTÄNDEN. Band I, Alt-

weissmetalle. By E. R. Thews. Carl Hanser Verlag, Munich, Germany, 1948. Cloth, $6^1/_2 \times 9^1/_2$ in., 359 pp., illus., diagrams, charts, tables, 22.50 DM. This detailed presentation of an important branch of the scrap-metal industry is divided into four sections. The first considers the economic importance of scrap metals and their working range. The second discusses the general treatment and preparation of old and scrap material, the treatment of zinc residues, lead residues, white-metal slag and scrap, and fine dust, fluxes, and steam agitation of metals and alloys. The third covers smelting equipment, reverberatory furnaces, rotary furnaces, and fuels. The fourth contains useful tables.

Plastics in Engineering. (Machine Design Series.) By J. Delmonte. Third edition. Penton Publishing Company, Cleveland, Ohio, 1949. Fabrikoid, $6 \times 9^1/_2$ in., 646 pp., illus., diagrams, tables, $10. Of value to the practicing engineer and the engineering student, this third edition, like its predecessors, analyzes plastics from the viewpoint of the designer and engineer. The material has been extensively regrouped, and chapters follow a pattern of materials, properties, methods, and applications. Since the greatest development during the past few years was in the properties of plastics, this section is greatly expanded. New materials and processes are also included.

Power Capacitors. By R. E. Marbury. McGraw-Hill Book Co., Inc., New York, N. Y., Toronto, Canada, London, England, 1949. Cloth, $6 \times 9^1/_4$ in., 205 pp., illus., diagrams, charts, tables, $3.50. Of value to both engineers and those with little technical background, this book covers the fundamental working principles, materials used in the manufacture, and the characteristics of completed units of power capacitors. It traces the history and development of capacitors and their applications to power systems. It provides an abundance of detailed data about the installation and maintenance of capacitors, new developments, and accessories.

Professional Registration Laws and the Engineer. (A Study of Engineering Registration Laws.) By A. M. Sargent, author and publisher, 19669 John R St., Detroit 3, Mich., 1948. Paper, $5^1/_2 \times 8^1/_2$ in., 60 pp., illus., $.75. Of interest to the engineering profession, this pamphlet discusses engineering licensing laws in the various states and their effects on engineers and engineering.

Pulvermetallurgie und Sinterwerkstoffe. By R. Kieffer and W. Hotop. Second edition. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1948. Paper, $6^1/_4 \times 9^1/_2$ in., 412 pp., illus., diagrams, charts, tables, DM 36. The principles and practices of powder metallurgy and sintered material are considered. Divided into four parts, part one contains discussion of raw materials and methods of operation used in powder metallurgy. Part two presents the scientific principles of powder metallurgy with specific attention to the properties of sintered bodies. In part three, sintered metals and alloys are discussed, and part four is devoted to the technique of sintering specific materials. Bibliographies follow each chapter.

Royal Society Scientific Information Conference, June 21–July 2, 1948. Report and Papers Submitted. Royal Society, Burlington House, London, England, 1948. Cloth, $5^1/_2 \times 8^3/_4$ in., 723 pp., illus., diagrams, charts, tables, £1, 5s; $6, U.S.A. The first 200 pages of this publication cover the organization and activities of the conference and the reports of the working parties or committees. The majority of the latter part, some 470 pages, contains the separate papers dealing with needed and possible improvements in methods of publishing, distributing, collecting, indexing, abstracting, and reproducing scientific literature.

Simplified Graphical Distribution of Moments in Rigid Frames. By A. A. Eremin. The author, 1541—37th St., Sacramento 16, Calif. Paper, $8^1/_2 \times 11$ in., diagrams, charts, tables, photo-offset, $3. The method presented in this pamphlet is similar to that in the author's previous book on the "Analysis of Continuous Frames." Various improvements, however, have been made. The diagrams have been rearranged, and the graphical constructions have been classified by solving the numerical examples from practice.

Steel and Its Heat Treatment, Volume 3. Engineering and Special-Purpose Steels. By D. K. Bullens and the Metallurgical Staff of the Battelle Memorial Institute. Fifth edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, Ltd., London, England, 1949. Cloth, $6 \times 9^1/_4$ in., 606 pp., illus., diagrams, charts, tables, $7.50. This final book of a three-volume set correlates the known facts about the more important alloy or special steels and their heat-treatment with fundamental principles. Presented in three sections, the book treats in order engineering alloy steels, constructional alloy steels for heat-treating, and special steels. The effect of heat-treatment on the suitability of these steels for various uses is analyzed, as are the possibilities of utilizing alternate steels.

Streamline Flow. By H. F. P. Purday. Constable & Company, Ltd., London, England, 1949. Cloth, $5^1/_2 \times 8^3/_4$ in., 185 pp., diagrams, charts, tables, 18s. This book is an introduction to three closely related parts of physics: mechanics of nonturbulent flow; the flow of heat by conduction; and heat transfer between solids and fluids in states of nonturbulent flow. There is a threefold emphasis on physics, mathematics, and technical applications. Only an elementary knowledge of the calculus is assumed.

Strength of Materials. By J. P. Den Hartog. McGraw-Hill Book Company, Inc., New York, N. Y., Toronto, Canada, London, England, 1949. Cloth, $6 \times 9^1/_4$ in., 323 pp., illus., diagrams, charts, tables, $4. Designed for use in a first course in the subject, this book is a companion volume to the author's "Mechanics," and employs the same notations and sign conventions. Written in a descriptive style, each article starts with general theory and then presents the practical examples of the theory. There are 350 problems, complete with answers, at the end of the text.

Strength of Materials. By C. O. Harris. American Technical Society, Chicago, Ill., 1949. Cloth, $8 \times 11^1/_2$ in., 214 pp., illus., diagrams, charts, tables, $4.90. Prepared not only for engineering students but also for others in industry who need such basic knowledge, this book presents a simplified discussion of the strength of materials. Each topic is developed in a step-by-step manner, and a set of practice problems follows each topic. Early chapters provide the needed background. The properties, advantages, and disadvantages of many materials are covered in detail. Topics receiving special attention include spot welding, fatigue in metals, and new materials which are currently being used in industry.

Structure and Properties of Alloys. By R. M. Brick and A. Phillips. Second edition. McGraw-Hill Company, Inc., New York, N. Y., Toronto, Canada, London, England, 1949. Cloth, $6 \times 9^1/_4$ in., 485 pp., illus., diagrams, charts, tables, $6. This revision of a widely known text has been expanded to include a large amount of new material, the discussion of additional alloys in existing chapters, the expansion of certain sections, and the addition of new chapters on magnesium alloys and on corrosion and heat-resistant steel alloys. The general approach of the first edition has been retained—the correlation of phase diagrams, structures, and properties of alloys, proceeding in order from the simplest alloys to the most complex.

Symposium on Deformation of Metals as Related to Forming and Service. (Special Technical Publication No. 87), presented at the Fifty-First Annual Meeting of American Society for Testing Materials, Detroit, Mich., June 22, 1948. American Society for testing Materials, Philadelphia, Pa., 1949. Paper, 6×9 in., 117 pp., illus., diagrams, charts, tables, $2. (ASTM members, $1.50.) This symposium focuses attention on developments that have taken place in recent years in dealing with some of the fundamental studies of plastic deformation and flow. It includes some newer methods of testing which give more fundamental information dealing with our metallic minerals.

Symposium on Functional Tests for Ball Bearing Greases. (Special Technical Publication No. 84), presented at the Fifty-First Annual Meeting of American Society for Testing Materials, Detroit, Mich., June 23, 1948. American Society for Testing Materials, Philadelphia, Pa., 1949. Paper, 6×9 in., 103 pp., illus., diagrams, charts, tables, $1.75. (ASTM members, $1.35.) The purpose of this symposium is to further develop and standardize acceptable methods and procedures for performance evaluation of ball-bearing greases. It assembles data collected by outstanding investigators on the functional methods used for testing and the significance they attribute to the results.

Symposium on Industrial Gear Lubricants. (Technical Publication No. 88.) American Society for Testing Materials, Philadelphia, Pa., 1949. Paper, 6×9 in., 21 pp., illus., diagrams, tables, $.75. The three papers presented cover studies of various field problems, as follows: heavy-duty gear oils; gear lubricants used in steel plants; and gear set servicing by the cathode-ray oscilloscope.

Symposium on Methods and Procedures Used in Identifying Reactive Materials in Concrete, presented at the Fifty-First Annual Meeting, American Society for Testing Materials, Detroit, Mich., June 24, 1948. American Society for Testing Materials, Philadelphia, Pa., 1948. Paper, $6 \times 8^3/_4$ in., 73 pp., illus., diagrams, charts, tables, $1.50. (ASTM members, $1.15.) The five papers included in this compilation describe test or identification methods, or present certain correlations of laboratory tests with field experience. The object of the symposium was to assemble information of assistance in preparing standard methods.

Technical Literature. By G. E. Williams. George Allen & Unwin, Ltd., London, England, 1948. Cloth, $5 \times 7^1/_2$ in., 117 pp., diagrams, tables, 7s, 6d. Following a brief introductory chapter the author considers three main aspects of presentation: ideas and their logical arrangement; the language in which the ideas are expressed; and their organization in paragraphs and sections. The preparation of manuscripts and illustrations in a form acceptable to societies and professional institutions is discussed in detail.

THE ENGINEERING PROFESSION

News and Notes

As Compiled and Edited by A. F. Bochenek

UNSCCUR Scientists and Engineers Explore State of World Resources

Optimism Characterizes Discussions

SCIENCE and technology have answers to shortages in world supplies of food, fuels, and minerals, causing concern among ecologists and government administrators, and await only a favorable political and economic climate to provide a better standard of living for the world's rapidly increasing populations.

This confident note became more and more apparent as 490 scientists and engineers from 38 nations attending the United Nations Scientific Conference on Conservation and Utilization of Resources (UNSCCUR) held at Lake Success, N. Y., Aug. 17-Sept. 6, 1949, exchanged information on what was being done in the laboratories of the world to develop new sources of food, new techniques of ferreting out deposits of fuels and minerals, and on what industry was doing to conserve natural resources through development of more efficient industrial processes and the generation and distribution of electric power.

Past-presidents E. G. Bailey and R. M. Gates were official delegates of The American Society of Mechanical Engineers to UNSCCUR. E. A. Pratt attended the conference as representative of the Engineers Joint Council.

First Nonpolitical UN Conference

Addressing this first UN-sponsored gathering of the world's technicians and experts on resources, Secretary-General Trygve Lie noted that this was the first time that the United Nations had called directly on the world of science to come together. Though meetings of scientists have been called before by the UN specialized agencies, he said, this Conference "which cuts across the fields of interests of several specialized agencies is necessarily the responsibility of the United Nations."

"The spectres of hunger and want—effective warmongers of the past—have been behind most wars.... Solutions to these problems though not so spectacular as those in the political field are of vital importance to world peace," declared Mr. Lie.

Mayor William O'Dwyer welcomed the Conference on behalf of the City of New York. "You are," he said, "that small group of this generation—pitifully small in every age—who see with utter clarity the problem before which all others fade away—the problem of man's survival in the universe."

In his welcoming address to the participants, United States Secretary of the Interior, Julius A. Krug, declared that the "good that this group can do is practically unlimited."

Standard of Living a World Problem

The greatest problem facing the world today is that of raising the standard of living of the people, not just maintaining it, said Mr. Krug. This could be accomplished, he added, by the intensive concentration of the world's scientific and engineering "know-how" on the "basic problem of making the most of what we have." Among the examples of the opportunities for using this know-how Mr. Krug mentioned the following: the peacetime application of atomic energy, the more effective utilization of solar energy, the development of synthetic fuels, and improved agricultural methods.

Detlev Bronk, chairman of the U. S. National Research Council and president of Johns Hopkins University, greeted the participating scientists on behalf of their American colleagues. Accordingly, American scientists, Dr. Bronk said, recognize a duty and a privilege to participate in development and protection of the natural resources of the world for the benefit of peoples everywhere.

Industrialization

"No country on the globe has attained economic maturity—or ever will, if there is to be continued progress," according to John Abbink, consultant on the Foreign Technical Assistance Program, United States Mission to the United Nations, who spoke at the 11th plenary session on assessing resources for industrialization.

Some people appeared to believe that the United States had reached some sort of peak in economic or material well-being, and had even suggested that the United States "might well assist the rest of the world in attaining economic equality before planning to further its own material progress."

This was a "misconception" as to the nature of the problem of economic development throughout the world, said Mr. Abbink. This was part and parcel of a "subversive doctrine"

TRYGVE LIE, SECRETARY-GENERAL OF UNITED NATIONS, GREETING WILLIAM O'DWYER, MAYOR OF NEW YORK, N. Y., AT THE OPENING SESSION OF UNSCCUR. JULIUS A. KRUG, UNITED STATES SECRETARY OF THE INTERIOR, IS STANDING IN THE BACKGROUND

that the world needs "not to produce more, but to divide what has been produced in the past."

The longing for economic progress, he added, seems universal; the question this generation must resolve "is how to inspire those who yearn to accomplishments."

Almost without exception, the countries "most vigorous in their demand" for outside assistance in what they call "economic development" emphasize manufacturing as the activity they wish to promote.

Yet, he continued, few of these countries were ready for the degree of industrialization "to which they seem to aspire."

To undertake industrialization at the "risk of hungry stomachs," or in the face of rising imports of food staples readily produced locally would be uneconomic development.

"The people of the United States have proven they are willing to help to the limit of their abilities, but they are little inclined to provide funds merely because some country wants them. There is too great need at home for capital," said Mr. Abbink in conclusion.

Creation of New Resources

On the subject of creation of new resources, Neville Woodward, director of the Scottish Seaweed Research Institute, described work being done on fodder yeast and algae. He named a new technology, chemurgy, as a potential source of resources. This technology, he said, involved the use of agricultural commodities and wastes as raw materials for secondary industry.

Dr. Woodward especially emphasized the use of seaweeds and plants for the creation of new resources. The dry content of seaweeds is rich in minerals and carbohydrates.

He also mentioned the new method of nutri culture by which plants are grown in substances other than soil—the chief kinds of nutri culture, he said, were sand culture, water culture, and subirrigation culture.

Dr. G. E. Hilbert, from the Bureau of Agricultural and Industrial Chemistry of the U. S. Department of Agriculture, referred to the facilities and information available in the United States to aid in the chemurgic training of scientists and technicians of other countries and urged efficient agricultural production, more scientific research, and aggressive industrial enterprise for achieving further success in the field of chemurgy.

Harry Lundin, of the Royal Institute of Technology (Sweden), elaborated on fat synthesis by microorganisms and its possible applications in the food industry. He said that the quantities of fat yeast which would be produced by this method in the near future would contribute to the improvement of the world's food situation.

Marine Resources

Investigation of shark-oil production in Egypt, and fish farming in China, Indonesia, and the Philippines were discussed by the delegates as promising ways to unlock more wealth from the world's fish and marine resources. Dr. I. Brahim Abou Samra, director of Fouad I Institute of Hydrobiology and Fisheries, Alexandria, Egypt, reported that three times the vitamin-A content of cod-liver oil could be

NORTH VIEW OF THE INTERIM HEADQUARTERS OF UNITED NATIONS, LAKE SUCCESS, N. Y. WHERE SESSIONS OF UNSCCUR WERE HELD, AUG. 17–SEPT. 6, 1949

obtained from liver-oil extract from sharks caught in Egyptian waters.

Herminio Rabanal, Bureau of Fisheries, Manila, Philippines, said that in his country there were almost 600,000 hectares of fresh and salt-water swamps which could be converted into fish ponds capable of producing as much as 200-million kilograms of fish annually.

World's Oil Reserves

A strong appeal to the governments of the world to take steps to appraise the world's total reserves of oil was made by Manuel Rodriguez Aguilar of Mexico and A. I. Leverson of the United States, who claimed that there was a potential reserve of oil to last for several hundred years. According to estimate, there was a potential reserve of 500,000 million barrels of oil under the surface of the earth, and another 1,000,000 million barrels in the continental shelves submerged under the oceans.

The Mexican oil expert urged that an international committee, under the United Nations or some other body, be set up to undertake such a survey on a world-wide scale.

The proposal was not submitted in the shape of a formal resolution, because UNSCCUR had not been authorized to make specific recommendations.

Stressing that such a survey could not be properly attempted by individuals but must be properly co-ordinated, Mr. Aguilar took exception to Mr. Leverson's statement that a free-enterprise and a profit-incentive system was the most effective in the search for petroleum deposits. In this connection, he gave examples from Mexico to prove that a nationalized industry could be equally effective.

Oil Discovery

A review of the latest techniques for oil and gas discovery and the new methods, instruments, and equipment being used in oil and gas production were the two main topics discussed at the August 25 meeting of the Fuels and Energy Section of UNSCCUR.

Under the chairmanship of Leon Jacques of the Institut Francais du Petrole, participating experts devoted the first part of their session to consideration and discussion of three technical papers dealing with the discovery or prospecting aspect of the oil and gas industries.

A paper prepared by G. M. Lees of the Anglo-Iranian Oil Company, stated that discovery techniques have reached such a degree of effectiveness that there is "reasonable certainty" the world's demand for oil supply will be met for "years to come." It pointed out that "no fundamental new discovery methods are expected," but added that undoubtedly existing techniques would be greatly defined.

The three successive phases of dominant discovery technique in the 90-year period since the first well was specifically drilled for oil by Colonel Drake were, he said, (1) seepage-drilling and "wildcatting"; (2) geological mapping; and (3) geophysical mapping of concealed geology.

The first two methods mentioned had been responsible for the bulk of past discovery, but geophysical methods were now dominant and would be "increasingly so" in the future. It was pointed out, however, that the latter methods which depend on the gravity, magnetic, and seismic principles were only an indirect method of discovery of oil, in that they were served only to determine underground structural forms which could be oil-bearing. They did not report directly on oil as such.

Oil Chemistry

A review of the present status and trends of oil chemistry and the production of synthetic fuels were the two main topics discussed by the Fuels and Energy Section of the UNSCCUR on August 29, 1949.

Participants heard Gustav Egloff, of the Universal Oil Products Company of Illinois, on a "Review of Present Status and Trends of Oil Chemistry."

About $112,000,000, which is 25 per cent of all industrial expenditures for research, are spent by the oil industry every year in the United States, declared Mr. Egloff.

Over 5000 commercial products were at present derived from crude oils, of which fuels for internal-combustion engines made up over 50 per cent. Of the fuels, gasoline was the most important. Crude oil, however, yielded only about 20 per cent gasoline.

Chemical research—cracking and other processes—had increased this yield to 45 per cent gasoline for every barrel of crude oil.

During the 36 years that the cracking process had been utilized, the increased yield and improved quality of the gasoline had "made unnecessary" the production of 30,000,000,000 barrels of crude oil in the United States alone.

Over 60 per cent of the 922,000,000 barrels of gasoline produced in 1948 in the United States had been cracked gasoline. The large volume and high quality of this type of fuel had made unnecessary the production of 2,500,000,000 barrels of petroleum in 1948 which would have been needed "if dependence were placed entirely on the gasoline naturally present in crude oil."

Coal Preparation

New techniques being used in the United States, France, and England in the preparation of coal as a means of expanding coking-coal reserves and permitting increased and more complete mechanization of production, was the principal topic of discussion at the August 24 meeting of the Fuels and Energy Section.

Delegates first heard H. F. Yancey of the United States Bureau of Mines, on the subject of coal-preparation techniques and problems in the United States.

The preparation of coal, said Mr. Yancey, occupied the "strategic middle position" in the series of consecutive operational steps that constitute the coal industry: production, preparation, and utilization.

As the production and utilization branches of the industry were "pressing ahead" independently on such "revolutionary developments" as "full-seam recovery" and "continuous mining," continued Mr. Yancey, it was the task of the preparation branch of industry to co-ordinate the activities of the other two branches "toward the common objective of employing our fuel resources with maximum economic effectiveness."

In current American experiences, he said, direct savings of fuel creditable to coal preparation were mainly in the field of "fine-coal" recovery. Nevertheless, the major concern in conservation of reserves was "focused" on coking-coal supply for the simple reason that this class of coal was "vastly less" than the reserves of fuel coal.

Coke Shortage

Various methods by which scientists and engineers were gradually overcoming the critical shortage of coke, an essential factor in the production of iron and steel, were also discussed.

G. W. Lee, director of the British Coke Research Association, pointed out that the coking industry as well as the gas industry drew on approximately the same sources of coal supply for production of their commodities. This fact among others was causing a rapid diminution in the reserves of available coking coal.

Moreover, said Mr. Lee, estimates made in the past in regard to coal reserves had been made on the basis of "insufficient data" and on the whole were "considerably overestimated."

The "time was ripe," he said, for a new and exact review of estimates to be made in this connection with the co-operation of geologists, surveyors, engineers, and other experts. Mr. Lee also felt that there was an "obvious need" for a system of classification or nomenclature of coals. At present coal was bought according to "trade names," the latter being used "very loosely."

L. L. Newman of the Bureau of Mines of the United States, added that improved cleaning methods and advancements in blending techniques would help the conservation of coke resources. A well-integrated research and development program to do away with the threat of future shortages "should be undertaken and supported by government and industry."

Mr. Newman related the manner in which temporary shortages of coke were relieved in the United States during World War II, and discussed the threat of continuing shortages resulting from the depletion of premium grades of coking coals. This threat, said Mr. Newman, could be met by increased exploration, by the conservation through limitations on the use of coking coal for other purposes than coke production, and by the reduction of mining losses.

Supply of Minerals

World-wide supplies of minerals and methods for their measurement was the general subject of discussion at the August 25 meeting of the Minerals Section of UNSCCUR.

The first speaker, Walter E. Pehrson, chief of the Economics and Statistics Division of the Bureau of Mines, U. S. Department of Interior, introduced and explained tables of estimates of selected world-mineral supplies by cost range.

In general, Mr. Pehrson was of the opinion that the outlook for major improvement with regard to mineral reserves was "not too favorable." He conceded that geologists expected great discoveries of raw materials, but with the cost of exploitation, prospects seemed to him rather limited. Any great improvement in the position of the United States in this regard, he declared, could not be expected.

Several speakers, mostly geologists, took a far more optimistic view of the world's mineral position than that elucidated in the statistics submitted. Others pointed out, however, that no matter how approximate these figures were, they nevertheless served a useful purpose in helping to visualize future programs.

Another topic, discussed by Alan M. Bateman of Yale University, was the geographical factors in the utilization of mineral deposits.

The chief geographical factors that determined whether a mineral deposit was utilizable, Mr. Bateman explained, were location, transportation, power resources, water supply, climate, labor, and food supplies. For the most part, he said, obstacles could be overcome by technical skill, provided the mineral deposits were of sufficient size and grade to justify the costs involved.

Water and Flood Control

The importance of forests and plants in controlling water and floods was the main theme of the August 24 meeting of the Water Section of UNSCCUR.

The section heard several speakers who gave accounts of the methods and systems used in different countries for the control of water through land management. These methods involved forestation and soil conservation.

Khan Bahadur Hameed, of the West Punjab Government of Pakistan, gave an abstract of a paper prepared by Dr. R. M. Gorrie, Conservator of Forests of West Punjab, which described the watershed management work done in the West Punjab area. According to the author, the main aim was to preserve the plant cover in a reasonable condition. If this was inefficient or insufficient, engineering devices—such as contouring, building of check dams, or terracing of the ploughlands—was needed.

Howard L. Cook, of the U. S. Department of Agriculture, said that water yields varied with the soil, vegetal cover, and the condition of the land. He gave examples where water yields were controlled by different methods of land treatment. He urged more extensive and co-ordinated studies of the problem of land management from the viewpoints of economy, hydrology, and legality.

1950 ASME Mechanical Catalog and Directory

THE thirty-ninth annual ASME Mechanical Catalog and Directory, 1950 edition, was distributed to ASME members during October.

In its catalog section, manufacturers decribe and illustrate many products of interest to mechanical engineers. This section is followed by a Directory which gives the user a practically complete and authoritative index to the following markets: Metals and alloys, power-plant equipment, power-transmission equipment, instruments, materials-handling apparatus, aircraft power plants and instruments, foundry and machine-shop equipment, heating, ventilating, and air-conditioning equipment, electric motors and controls, equipment for process industries, pumps, fans, compressors, and many other types of mechanical apparatus. A page-reference system in the Directory ties in with the catalog section providing descriptions of the desired machine or equipment.

According to the editors of the volume, it is the only book which covers the field of mechanical engineering so thoroughly.

A 20-page insert describing all ASME publications, such as power test, boiler construction, and safety codes, American Standards, fluid meters, engineering biographies, bibliographies, research reports, and manuals, is included in this volume for the ready reference of ASME members.

AEC Seeks Methods for Releasing Technological Information

Committee of 12 Appointed for Task

TWELVE representatives of engineering societies and the technical press were appointed recently by the Atomic Energy Commission to constitute a temporary advisory committee to assist in developing a trial program for examining selected declassifiable technological information of value to American industry and to expedite release of it to the engineering profession.

The members of the committee are: Sidney Kirkpatrick, chairman, McGraw-Hill Book Company, Inc., New York, N. Y.; H. A. Barton, American Institute of Physics, New York, N. Y.; Gene Hardy, Chilton Publications, Inc., Washington, D. C.; Keith Henney, McGraw-Hill Publishing Company, New York, N. Y.; Edward Kreutsberg, Penton Publications, Washington, D. C.; Harry Blank, Magazines of Industry, Inc., New York, N. Y.; Walter J. Murphy, American Chemical Society, Washington, D. C.; W. A. Phair, Chilton Publications, New York, N. Y.; J. J. Smith, American Institute of Electrical Engineers, New York, N. Y.; George A. Stetson, The American Society of Mechanical Engineers, New York, N. Y.; E. E. Thum, American Society for Metals, Cleveland, Ohio; and E. J. Van Antwerpen, American Institute of Chemical Engineers, New York, N. Y.

The purpose of the program is to determine the possibility of providing to industry information about pumps, blowers, valves, techniques of handling metals, and other metallurgical data which will be of immediate value to industry. The trial program will determine whether such selected information can be gathered, screened, and declassified for release in a way which will not reveal the specific relevance of the information to the atomic-energy program.

Working Group to Be Organized

The setting up of the advisory committee is the first step. This group will recommend members for a small working party of engineers, representatives of professional societies, and members of the business press in the field of metallurgy who will receive full security clearance. After the working group members are cleared, the Commission will make available for examination by the working party metallurgical information which may be declassifiable.

From the information made available to it, the working party will recommend to the Commission those portions which it believes should be considered for declassification because of their usefulness to American industry and technology. The Commission will exercise of course the final responsibility for declassifying any recommended material, taking into account the considerations against declassification as well as those favoring declassification.

Any information which the Commission may actually declassify would be made available for publication by established engineering and industrial journals in the field of metallurgy. If the trial program in metallurgy proves effective, the Commission will consider the application of similar procedures to other fields of technological and industrial information.

Objectives

The trial program is in response to the three-part recommendation of the Commission's Industrial Advisory Group that: (1) Already published material should be organized and clarified, and reports issued in a form useful to industry; (2) unpublished information of nonrestricted nature should be made available to industry in useful form; (3) information still classified, but properly declassifiable and of special interest to industry, should be surveyed and declassified.

Much of the present program of the Commission's Public and Technical Information Service is concerned with the dissemination of nonrestricted or declassified information. In the past the impetus for declassification and general distribution of atomic-energy information has come much more strongly from the scientific than from the engineering and technical groups. Out of a total of 2400 papers declassified up to Jan. 1, 1949, only 133 or 5 per cent are in the field of industrial technology. The trial program is expected to increase the amount of technological information to be considered for declassification.

Power-Industry Engineers to Study AEC's Reactor Program

Methods Sought to Initiate Industry Participation

PHILIP SPORN, Fellow ASME, and president of the American Gas and Electric Company, New York, N. Y., has been appointed by the U. S. Atomic Energy Commission as chairman of a three-man temporary advisory committee to recommend ways to establish continuing co-operation between the electric power industry and the AEC.

The objective of the new committee will be to inform itself regarding the Commission's reactor-development program in order to make recommendations as to the most practical means of establishing effective continuing contact within security limits between the AEC and the electric power industry. The committee's report on its survey and recommendations is expected to be completed by March 31, 1950.

Other members of the committee are Edward W. Morehouse, vice-president, General Public Utilities Corporation, New York, N. Y., and Walton Seymour, director of the Division of Power in the Secretary's Office, U. S. Department of the Interior.

In commenting on the establishment of the new committee, Chairman David E. Lilienthal of the AEC said:

"While we have long recognized the importance of closer co-operation with those industrial interests not under contract to the Commission, the need was highlighted in last winter's report by an Industrial Advisory Group headed by James W. Parker. We have given a great deal of thought to this problem and now feel it is time to explore more intensively the ways and means by which closer co-operation between the Commission and the electric power industry can be achieved."

Mr. Sporn has been a leading figure in the affairs of the electric industry and is recognized as an authority on problems of energy supply. During the war Mr. Sporn was adviser to the Office of Production Management and the War Production Board, and assisted military authorities in re-establishing utility services in Europe following the Allied landings. He is a member of the Electric Power Committee of the National Security Resources Board.

Members of the new committee, who have been cleared for access to whatever data in the reactor field they may need to carry out the project, will conduct a firsthand examination of programs and technical information in the AEC's reactor-development program.

One important aspect of the committee's work will be the machinery it will devise for clearing the way for appropriate groups and engineers of the power industry to a better understanding of the problems involved in the Commission's reactor-development work. The committee's report is expected to enable the industry to participate in properly defined areas of that work and to utilize its specialized technological resources to contribute to the solution of problems in this field for the mutual advantage of the Commission, the power industry, and the public.

It is also hoped that through this program it will be possible to identify declassified and further declassifiable technical information on reactor development which may be useful to the engineering profession.

EJC National Defense Questionnaire

IS it still on your desk unanswered? You are one of 100,000 qualified professional engineers selected by the Office of Naval Research to be included in a national who's who in engineering research and development. Already 30,000 of your colleagues have filled out and returned the questionnaire. You are urged to do your part.

Progress Noted in State Engineering Registration Laws

A RECENT survey on what has been happening to the engineering registration laws of the individual states shows that there is a definite trend toward raising the standards of registration by improving methods of giving examinations, granting interstate registration, and adopting amendments providing for the certification of the engineers in training.

The study was conducted by T. Keith Legaré, executive secretary of the National Council of State Boards of Engineering Examiners, and chairman of the Committee on Registration of Engineers of the American Society of Civil Engineers.

According to Mr. Legaré, the engineers-in-training programs are winning the enthusiastic support in most states and engineering educators are becoming more interested in putting it in effect.

Thirty of the state boards report that they do not plan any amendments this year or next. Some boards believe their present laws are operating very satisfactorily and do not wish to propose minor changes through fear that such legislation may result in undesirable amendments. Many of the boards still control the funds paid in by registered engineers for administration of the Act, and these hesitate to change their registration laws in other respects as the provision for handling finances may be tampered with. In most states the proposed amendments are sponsored by the state engineering society, with the approval and co-operation of the state board. However, in a few states the changes are promoted by the state board, and the members of the profession do not always seem to recognize their opportunity for service and their responsibility to the public.

Twelve states have amended their registration laws during the past two years—some as recently as March, 1949. These states are Alaska, Arizona, California, Indiana, Kansas, Maryland, Minnesota, Nevada, New Jersey, New York, Oregon, and South Carolina. The majority of these amendments are for the purpose of providing for the certification of engineers in training.

Foundry Industry Looks to Engineering Schools

BEGINNING in 1950, five more engineering colleges will participate in the program sponsored by the foundry industry through the Foundry Educational Foundation to raise the engineering standards in the industry by promoting a program of scholarships designed to secure more engineers, and to provide more foundry courses to all engineering students.

New schools joining the program are: Ohio State University, Purdue University, Michigan State College, Pennsylvania State College, and the University of Missouri School of Mines and Metallurgy.

In its first three-year cycle the Foundation has awarded 148 scholarships to 102 students in seven co-operating engineering schools.

The dearth of courses, textbooks, and laboratory equipment in foundry engineering has left engineering students in almost complete ignorance of the possibilities for engineers in this five-billion-dollar industry.

Young engineers, generally, have been overlooking the opportunities in the foundry industry during the past decade because of the glamor of the newer technologies. As a result, the industry has been having difficulty in attracting enough engineers to take care of the normal annual mortality in its supervision, technical, and management brackets. Of its 30,000 top men, about 10 per cent, it is estimated, are lost annually through retirement or other causes. The Foundation hopes that within 25 years 60 per cent of the 3000 men needed annually will come from the engineering ranks.

Fourth World Power Conference to Be Held in London, July 10–15, 1950

Many ASME Members to Submit Papers

MORE than ten members of The American Society of Mechanical Engineers are among the American engineers who will present papers before the Fourth World Power Conference to be held in London, England, July 10–15, 1950. The conference will treat, from the engineering and economic viewpoints, as distinct from the administrative and political, the theme "World Energy Resources and the Production of Power."

The tentative program consists of 136 papers by authors from 20 countries, arranged in the following three divisions: Energy resources and power developments; preparations of fuels; and production of power.

United States participation is being sponsored by the United States National Committee of the World Power Conference of which Gano Dunn, Hon. Mem. ASME, is chairman, and H. C. Forbes is treasurer and secretary.

Papers by ASME authors will cover such subjects as trends in mechanical mining and preparations of coal, synthetic liquid fuels, transportation, storage and peak-load capacity in the natural-gas industry, trends in American boiler performance requirements, trends in developments in steam-turbine practice for central-station service, a progress report of the mercury-cycle power generation, and others.

Tours of Great Britain are being arranged for the following week, to end on Sunday, July 23. These will include matters of technical concern and places of scenic and historic interest.

Women accompanying members of the conference are invited to the opening and closing meetings and the tours. Arrangements are being made for their entertainment during the week of the meetings.

Steamships for Atlantic crossings next July are already heavily booked. Reservations will soon be hard to get. The British committee on arrangements calls attention to the urgency of this matter.

Thomas Cook and Sons, Limited, have been designated by the British committee as official travel and hotel agents for the conference. Their main office in the United States is at 587 Fifth Avenue, New York 17, N. Y. C. L. Hilll at that office is familiar with the conference arrangements.

A bulletin giving more details of the program and arrangements is expected to be available by November, together with application forms for conference membership. Inquiries may be addressed to United States National Committee, World Power Conference, 4 Irving Place, New York 3, N. Y.

Codes and Standards

ISO Starts Work on World-Wide Screw-Thread Standards

A FAVORABLE start toward unification of the various national standards on screw threads was made at the three-day meeting of the International Standardization Organization held in Paris, France, June 28–30, 1949. Delegates from 15 of the 18 countries represented voted to recommend the recently established Unified Anglo-American Screw Thread to their national standardizing bodies as the common profile for the metric and inch systems of screw threads.

U. S. Delegation

United States delegation to the ISO discussions was headed by George S. Case, chairman of the board, The Lamson and Sessions Company, Cleveland, Ohio. Other members of the American Standards Association Sectional Committee B1 on Standardization and Unification of Screw Threads, of which The American Society of Mechanical Engineers is one of the sponsors, were: I. H. Fullmer, senior physicist, National Bureau of Standards, Washington, D. C.; W. H. Gourlie, standards engineer, Sheffield Corporation, Hartford, Conn.; and R. F. Holmes, General Motors Corporation, Flint, Mich. John Gaillard, ASA staff, served as adviser to the U. S. delegation.

The vote of the French delegates was hedged

with two reservations: (1) That this profile be adopted as a world-wide profile; (2) that the overlap for large diameters and small pitches remain acceptable after tolerances have been applied which are compatible with the possibilities of present-day engineering practice. Russian delegates, casting the only negative vote, had come to the meeting instructed to support the Zurich 1939 profile, somewhat similar to the Unified Anglo-American Screw Thread.

Five Resolutions Adopted

Czechoslovakia abstained from voting, while Italy agreed to recommend the Anglo-American thread for the inch system of screw threads only.

The vote on the Anglo-American thread was one of five resolutions adopted by the delegates. Sweden acted as secretariat for the countries represented. Other countries were: United States, Great Britain, France, Russia, Poland, Belgium, Canada, Denmark, Finland, Portugal, Hungary, Israel, The Netherlands, Norway, Switzerland, Czechoslovakia, and Italy.

The other resolutions established:

(1) A subcommittee composed of France, Italy, Czechoslovakia, The Netherlands, Poland, Sweden, Switzerland, United States and Russia, to define the scope of the Technical Committee, known as ISO-T1.

(2) That the Unified Anglo-American Screw Thread would be referred to as the "ISO Basic Profile."

(3) The program of work for the Technical Committee as:

Profile, diameter-pitch series, and preferred diameters and pitches for (*a*) threads of bolts and nuts with triangular profile smaller than 6 mm diameter; (*b*) threads for bolts and nuts with triangular profile 6 mm diameter and larger; and (*c*) constructional threads with triangular profile 6 mm diameter and larger.

(4) A working commission to assist the secretariat and aid in the preparation of documents and the presentation of data for the Technical Committee was appointed. The committee: United States, Great Britain, France, Switzerland, Sweden, and Czechoslovakia.

The scope of the Technical Committee was defined as: "the establishment of a series of internationally interchangeable screw threads covering the technical requirements in various fields of application with a minimum variety of basic profiles, pitches, and diameters. The unification of American and British pipe threads is not included in this scope."

Pressure-Piping Codes Undergoing Revision

THE Sectional Committee on the Code for Pressure Piping, ASA-B31, has been reorganized under the chairmanship of F. S. G. Williams, Taylor Forge and Pipe Works, New York, N. Y., with Sabin Crocker, Ebasco Services, Inc., New York, N. Y., as vice-chairman, and Lester W. Benoit, Manufacturers Standardization Society of the Valve and Fittings Industry, New York, N. Y., as secretary.

The present Code for Pressure Piping, with Supplement No. 2, as approved by the American Standards Association on April 7, 1947, is up for consideration and for revision.

The air-conditioning and refrigerating industry will be interested to learn that section 5, covering refrigeration-piping systems of the Code for Pressure Piping, is up for revision under the chairmanship of A. C. Buensod, New York, N. Y. The air-conditioning and refrigerating industry is also cognizant of the fact that the B-9 Safety Code for Mechanical Refrigeration, sponsored by the American Society of Refrigerating Engineers under the ASA procedure is also in the stage of being revised.

In both the present Code for Pressure Piping, ASA-B31, and in the ASA Standard for Mechanical Refrigeration, B-9 Refrigerant Piping is included. It is therefore only natural that there should be a very close co-ordination between these two codes, as obviously the piping requirements should be the same for each of the codes. There is an indication that is quite general among the committee members that the Code for Pressure Piping should contain the Refrigerant Piping and be the basis for piping that is to be used in the B-9 Safety Code for Mechanical Refrigeration.

Because of the wide interest that has been displayed in the revision of both of these codes, the committee members for each of the codes wish to obtain all the help and comments possible from the various segments of the industry, including producers, suppliers, contractors, and users. Mr. Buensod, the chairman of the refrigeration-piping section of the Pressure Code for Piping, wishes to enlist the support of all of these segments, and any suggestions made will receive due consideration.

The Committee on Refrigeration Piping will consist of approximately 10 voting working members. The scheme of the Sectional Committee also permits corresponding members, who may sit in on all meetings. Such corresponding members do not have a vote but by correspondence can submit very valuable contributions in the way of comments so that the members of the committee may have the best advice from the entire industry.

Mr. Buensod would gladly consider the names of men in the industry who wish to participate in the work of the Committee on Refrigeration Piping. His address is: A. C. Buensod, 60 East 42nd Street, New York, N. Y.

ASME Power Test Codes

THREE revisions to the Power Test Codes of The American Society of Mechanical Engineers have recently been published. These are: "Steam Turbines PTC 6-1949"; "Appendix to Steam Turbines PTC 6-1949"; and "Internal-Combustion Engines PTC 17-1949."

The power test code for steam turbines is a revision of the 1941 edition and corrects and clarifies some of the ambiguities of the older edition. The 93-page code defines text procedures for all types and applications of steam turbines and includes instructions for correction of test results for deviations of test conditions from those specified. Rules are established by the code for conducting tests of a steam turbine to determine capacity, steam or heat consumption, engine efficiency, and emergency-governor operation. Price is $2.

The "appendix to the power test code for steam turbines" is an 85-page booklet whose purpose is to facilitate the working up of test reports. It provides numerical examples of many of the calculations that are involved in tests of steam turbines carried out under the ASME code for steam turbines. In the new edition an amendment has been made covering the formulas for flow measurement by the enthalpy-drop method. Price of the appendix is $2.

The new edition of the power test code for internal-combustion engines is a complete revision of the 1929 code. Rules for testing, methods for instrumentation, and procedures for evaluating results have been brought into line with current requirements for determining the performance of all types of modern reciprocating internal-combustion engines. The code provides rules for testing, computation, and tabulation of test results for all forms of internal-combustion engines including gasoline, gas, and oil or dual-fuel engines. The primary object of the tests defined by the 50-page code is the determination of net power output under specified speeds and operating conditions and engine fuel or heat consumption. Price is $1.50.

Copies of the codes may be purchased from ASME Publication-Sales Department, 29 West 39th Street, New York 18, N. Y.

Formulation of power test codes is one of the major activities of The American Society of Mechanical Engineers. The work is carried on by the ASME Power Test Codes Committee under the chairmanship of A. G. Christie, Fellow and past-president ASME. Since its organization in 1918 the committee has expanded its program until today there are 24 subcommittees composed of more than 200 authorities in the power field, working under its jurisdiction on power test codes covering boilers, steam engines, steam and gas turbines, pumps, blowers, fans, condensers, refrigerating systems, and others.

Hydraulic Turbines

A revision to the 1938 Test Code for Hydraulic Prime Movers was recently published by The American Society of Mechanical Engineers. The Code, which deals with standard and approved practices for testing of individual reaction and impulse water wheels, has enjoyed general acceptance by industry in the United States and Canada as the basis for contract testing of hydraulc turbines.

In the new edition, paragraphs 17, 56, and 85 have been rewritten, and some footnotes and several paragraphs were deleted. These minor changes did not warrant complete rewriting of the Code.

S. Logan Kerr, Mem. ASME, consulting engineer, Philadelphia, Pa., chairman of ASME Power Test Codes Individual Committee No. 18 on Hydraulic Prime Movers, is responsible for the formulation of the Code.

Copies may be obtained from ASME Publication-Sales Department, 29 West 39 Street, New York 18, N. Y. Price per copy is 85 cents.

Refrigeration

THE sixth edition of Refrigeration Fundamentals was recently published by The American Society of Refrigerating Engineers. The volume contains 42 chapters by authorities in the refrigeration and air-conditioning industry, and covers a wealth of new material and data on latest developments and practices. Over 900 pages of information including 233 tables and 362 illustrations make the volume a complete handbook of refrigeration and air conditioning.

Copies may be obtained from ASRE, 40 West 40th Street, New York 18, N. Y. Price is $7.

Notes on Coming Meetings

THE American Association for the Advancement of Science will hold its 116th meeting in New York, N. Y., Dec. 26–31, 1949. All 17 sections and subsections of the association and 53 societies are participating, and meetings will be conducted concurrently at the Statler, New Yorker, McAlpin, Martinique, and Governor Clinton hotels. There are more exhibitors than ever before; from every indication the attendance will be the largest in the 101-year history of the association.

An invitation is extended to the members of ASME to attend the symposiums on physics, science in general education, and the improvement of the teaching of science on the college level; all conducted by outstanding authorities. Meetings of special interest to engineers, designated as Section M, will be held at the Statler Hotel, New York, N. Y.

Plastics

THE 1950 National Plastics Exposition will be held at Navy Pier, Chicago, Ill., March 28 to 31, 1950. As shown by the three previous expositions, the 1950 showing is expected to attract exhibitors and attendance from throughout commerce and industry. The adaptability and versatility of plastics have made it and its products important in nearly every manufacturing and retail field.

The new importance of promotion and merchandising to the industry helped determine the choice of Chicago. Both industrial manufacturers and retailers are the end-users of plastics, and Chicago is a center for both, as well as being a center of one of the largest concentrations of plastics manufacturing. Proximity to the automobile market in Detroit, Mich., was also a factor.

Exhibitors will include those who mold, extrude, laminate, and fabricate plastics products. The late March dates chosen will permit the presentation of what is newest in plastics at the time of year buyers and fabricators are planning their autumn and holiday programs.

Air Pollution

NATION-WIDE scientific activity in the field of air pollution has grown to such magnitude that a National Symposium on Air Pollution, sponsored by Stanford Research Institute in co-operation with the California Institute of Technology, the University of California, and the University of Southern California, will be held on Nov. 10–11, 1949.

The symposium, to be held at the Huntington Hotel, Pasadena, Calif. will bring together scientists, engineers, and other technical personnel from coast to coast in the field of air pollution. The program will include presentation of papers and interchange of ideas and methods of analysis and control of air pollution. The meeting will serve to stimulate increased interest in the important and complex problems of air pollution as approached on a sound scientific and technological basis.

Present plans indicate the two-day symposium will cover some or all of the following subjects: Biological effects on plants and animals; medical effects; effect on visibility; meteorological aspects; methods of sampling and analysis; reduction or elimination of air pollution at its source; and influence on industrial planning and plant location.

Time Study

THE 13th annual Time and Motion Study Clinic sponsored by the Industrial Management Society will be held at the Sheraton Hotel, Chicago, Ill., Nov. 2–4, 1949. Charles Sawyer, U. S. Secretary of Commerce, will head a group of nationally prominent leaders of labor, management, and government who will discuss methods and means of winning the "cold war on industrial inefficiency."

During the three-day seminar there will be eight sessions and the list of topics for discussion cover methods, plant layout, materials handling, time-study techniques, incentives, and many others of equal interest.

Safety

THE 37th annual convention of the National Safety Council will be held in Chicago, Ill., Oct. 24–28, 1949. Sessions on industrial safety will be held at the Stevens, Congress, and Morrison Hotels.

A feature of the congress will be a labor-management safety symposium on what can be done by labor organizations and industry to reduce off-the-job accidents. Labor's viewpoint will be presented by James L. McDevitt, president, Pennsylvania Federation of Labor, AFL, and Harry Read, executive assistant to the secretary-treasurer, CIO.

A display of radiological protective equipment by the Oak Ridge National Laboratory of the U. S. Atomic Energy Commission will be part of the industrial exposition in the Stevens Hotel.

Meetings of Other Societies

Oct. 3–6, 1949
Association of Iron and Steel Engineers, annual convention, Hotel William Penn, Pittsburgh, Pa.

Oct. 11–14
American Standards Association, Inc., annual meeting, Hotel Waldorf-Astoria, New York, N. Y.

Oct. 17–21
American Institute of Electrical Engineers, midwest general meeting, Netherland Plaza Hotel, Cincinnati, Ohio

Oct. 17–21
American Society for Metals, national metal congress, Hotel Statler, Cleveland, Ohio

Oct. 24–26
American Gear Manufacturers Association, semi-annual meeting, Edgewater Beach Hotel, Chicago, Ill.

Oct. 24–29
American Welding Society, 29th annual meeting, Bellevue-Stratford Hotel, Philadelphia, Pa.

Nov. 2–4
American Society of Civil Engineers, fall meeting, Hotel Statler, Washington, D. C.

Nov. 3–4
Society for Advancement of Management, annual conference, Hotel Statler, New York, N. Y.

Nov. 6–10
American Institute of Chemical Engineers, annual meeting, Hotel William Penn, Pittsburgh, Pa.

Nov. 9–12
The Society of Naval Architects and Marine Engineers, 57th annual meeting, Hotel Waldorf-Astoria, New York, N. Y.

Nov. 30–Dec. 2
Society for Experimental Stress Analysis, annual meeting, Hotel New Yorker, New York, N. Y.

Dec. 4–7
The American Society of Refrigerating Engineers, 45th annual meeting, Edgewater Beach Hotel, Chicago, Ill.

Dec. 26–31
American Association for Advancement of Science, annual meeting, Pennsylvania Station zone hotels, New York, N. Y.

(For Coming ASME Meetings see page 878)

Metals Casting

THE second annual Metals Casting Conference, sponsored by Purdue University in co-operation with the Michigan and Central Indiana chapters of the American Foundrymen's Society, will be held at Purdue University, Lafayette, Ind., Nov. 3–4, 1949.

A discussion of foundry costs, together with methods of determining costs, and cost reduction, by experts in the field and Purdue staff members, will be an important feature of the two-day program. There will be technical sessions on various aspects of metals casting and a motion picture from the American Foundrymen's Society on metal flow in molds. Quality control in foundry work will also be discussed. The group will visit the sand-testing laboratory at Purdue on the final day of the conference.

Among those on the committee in charge of the program are: Prof. H. A. Bolz, Roy W. Lindley, C. T. Marek, and S. C. Massari, members of ASME.

On Nov. 3, 1949, the annual banquet will be held at the Purdue Memorial Union Building, with an outstanding speaker on a topic of general interest. Selected student members of the Purdue honorary societies will be guests.

Hydraulics

THE National Conference on Industrial Hydraulics will hold its fifth annual meeting at the Sheraton Hotel, Chicago, Ill., Oct. 26–27, 1949. Sidney F. Musselman, Mem. ASME, is conference secretary and one of its founders; Otto H. Maha, Mem. ASME, is director of the conference. Until the founding of the national conference five years ago there was no meeting at which only industrial hydraulics problems were discussed.

The two-day program will present technical papers by some of the most authoritative speakers in the field of industrial hydraulics. Among the papers to be read covering recent developments, hydraulic equipment components, design considerations, hydraulic equipment standard, and hydraulic circuit performance are: Large Hydraulic Valves, by J. Fisch, Mem. ASME; Some Applications of Fluid Mechanics to Mixing, by Dr. J. Henry Rushton, Mem. ASME; and E. Wiedmann, Mem. ASME, will discuss the effects of the Joint Industry Conference's Hydraulic Standards on the manufacturers of industrial equipment.

Petroleum

AT THE 29th annual meeting of the American Petroleum Institute, Stevens Hotel, Chicago, Ill., Nov. 7–10, 1949, of interest to mechanical engineers, will be a session on fuels, Thursday, Nov. 10, at which the subject of the future of fuels and the relation of fuels to U. S. domestic security will be discussed. Speakers will be W. M. Holaday, Socony-Vacuum Oil Company, Inc., New York, N. Y., and Walter G. Whitman, Massachusetts Institute of Technology, Cambridge, Mass. Mr. Holaday will address himself to efficient uses of fuels, while Mr. Whitman will take up such broad matters as responsibility of national security as it is affected by availability of fuels, future requirements, and the timing of discovery and development of oil fields.

Heat Transfer

THE American Society of Mechanical Engineers plans to take part in the Heat Transfer Symposium to be held in London, England, in 1950. The members of the ASME Committee on Participation recently appointed are: John A. Goff, Applied Mechanics; A. L. London, Gas Turbine Power; A. P. Colburn, Heat Transfer; F. G. Hechler, Oil and Gas Power; and J. I. Yellott, Power.

Education

EFFECTIVE Dec. 1, 1949, the Pre-Engineering Inventory national testing program for engineering students will be merged with the more widely available testing programs of the College Entrance Examination Board.

The Pre-Engineering Inventory, to be discontinued as a separate program, is a battery of aptitude examinations developed by the Engineers' Council for Professional Development, and administered as part of the program of the Measurement and Guidance Project in Engineering Education, a joint project of the Carnegie Foundation for the Advancement of Teaching, The American Society for Engineering Education, and the ECPD.

A. Pemberton Johnson, Mem. ASME, until July 1, 1949, co-ordinator of personnel guidance for the Schools of Engineering at Purdue University, has been named project director of the Measurement and Guidance Project in Engineering Education, effective July 1. Dr. Johnson, 1939–1941 secretary to the Committee on Engineering Schools of the Engineers' Council for Professional Development, is a member of The American Society of Mechanical Engineers, and of the American Society for Engineering Education, and a long-time associate member of the American Psychological Association, with sixteen years' testing experience in business, education, and the armed forces.

People

CHARLES E. WILSON, Mem. ASME, and president, General Electric Company, was hailed by the national press on the occasion of his completing 50 years with GE on Sept. 1, 1949. Many social and company ceremonies in honor of the event are currently being held.

Mr. Wilson literally grew up with the company which was only seven years old at the time he joined it in 1899 as a twelve-year-old office boy earning $3 a week. He subsequently worked in the shipping, accounting, production, engineering, manufacturing, and marketing departments. He was made merchandising manager and vice-president in 1930, executive vice-president in 1937, and president of the corporation on Jan. 1, 1940.

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ROBERT H. BACON, Mem. ASME, has been elected president of the Chicago Technical Societies Council for 1949–1950. He is vice-president of the Industrial Advertising Agency of Kreicker and Meloan, Inc., and president of R. H. Bacon and Company. For the past 25 years he has been active in engineering-society work in Chicago, Ill., having been chairman of the Chicago Section of ASME in 1928, and president of the Chicago Engineers Club in 1947.

* * *

HUBER O. CROFT, Mem. ASME, Manager, 1940–1943, has been appointed dean of the college of engineering of the University of Missouri. According to the recommendation approved at a recent meeting of the Board of Curators, he will also be director of the Engineering Experiment Station and professor of mechanical engineering. He assumed his duties Sept. 1, 1949.

Professor Croft was formerly head of the mechanical-engineering department at the State University of Iowa, Iowa City, Iowa.

* * *

H. L. MINER, Mem. ASME, manager, Safety and Fire Prevention Division, E. I. du Pont de Nemours and Company, Inc., Wilmington, Del., was named chairman of the Safety Code Correlating Committee of the American Standards Association at its recent meeting. The committee is the top technical group in charge of the development of national safety standards of the association.

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WILLIAM HALSE MILLSPAUGH, Mem. ASME, of Sandusky, Ohio, has been awarded the Edward Longstreth Medal of The Franklin Institute of the State of Pennsylvania. The medal is given in recognition of Mr. Millspaugh's outstanding contributions to the art of papermaking, and his introduction and promotion of the art of centrifugal casting. He developed and patented suction rolls and papermaking devices which helped establish new world records for speed and production of paper.

* * *

THOMAS L. FAWICK, president, Fawick Airflex Clutch Company, Inc., Cleveland, Ohio, has been chosen as one of this year's winners of the John Price Wetherill Medals of The Franklin Institute. This Wetherill Medal was awarded in recognition of his adaptation of the well-known qualities of rubber expansion, flexibility, and durability in a clutch which has been widely and successfully used both in industry and in the U. S. Navy. Fawick has many patents to his credit.

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HENDLEY N. BLACKMON, Mem. ASME, has been appointed assistant manager of Engineering Association Activities for Westinghouse Electric Corporation. His headquarters are at the East Pittsburgh Works. Mr. Blackmon has been managing editor of *Electrical World* since 1947.

ASME NEWS

Engineering in Peaceful World Keynote of 1949 ASME Annual Meeting

Headquarters: Hotel Statler, Nov. 28–Dec. 1

TEN years after the cataclysm of war, bursting upon a troubled world gave the American engineering profession its golden hour of achievement, The American Society of Mechanical Engineers at its 1949 Annual Meeting to be held at the Hotel Statler (formerly Pennsylvania Hotel), New York, N. Y., Nov. 28–Dec. 1, 1949, is again addressing itself to engineering contributions to a peaceful world.

This theme will be developed in technical sessions and social events beginning with the President's luncheon on Monday, Nov. 28, at which Lillian M. Gilbreth, Fellow ASME, will speak on "The Share or Role of Women in Design." The next day Cornelius Vanderbilt Whitney, assistant secretary, U. S. Department of Commerce, will discourse on what engineers can do for world peace.

Instead of production and armaments, talks at the technical sessions will be on wood finishes for pianos and fine furniture, isotopes as tools of engineering, new techniques in air-cargo handling, performance of the Illinois smokeless furnace in homes, the potentialities of a 4000-hp gas-turbine locomotive for passenger service, and scores of other subjects which reflect progress and an even higher standard of living in an economic climate of incentive and capitalism.

It is a program that will dismay the collectivists and drive them to new heights of hysteria. At home, American engineers will accept it casually as the run-of-the-mine product of American enterprise, characteristically reflecting progress but introducing nothing radically new to alter the course of human affairs.

Standing out among the other interesting dinners and luncheons planned is the banquet at which Dr. H. J. Gough, president of The Institution of Mechanical Engineers of Great Britain, will discuss peacetime engineering overseas. His address will precede a talk by President James M. Todd. William A. Hanley, past-president ASME, will be toastmaster.

Junior Session

The National Junior Committee which has been functioning since 1947, when it was appointed by President Eugene W. O'Brien, is planning to sponsor an evening session on Tuesday, Nov. 29, 1949, at which three speakers working with young engineers will discuss employment trends, the how and why of professional development, and new opportunities in engineering, under the general theme "The Junior Engineer in 1950."

Earlier in the day, the Junior Committee will hold an open business meeting to which all juniors are invited. The chairman will review the work of the Committee, discuss policies of the Junior Forum, and the program for 1950. This is a meeting young members of the Society should not miss.

College Reunions

Because the Annual Meeting attracts so many engineers from all parts of the country, it provides the occasion for many reunions of engineering schools. This year Thursday, Dec. 1, has been selected as reunion day. Members who wish to organize reunions are urged to write to headquarters as soon as possible. The following information is required for inclusion in the final program: whether dinner or luncheon reunion, price, place, and name, address, and telephone number of person in charge of arrangements.

Hotel Reservations

October is not too early to write for room reservations for the Annual Meeting. This step should be taken before Oct. 17 to avoid disappointment. When asking for rooms, members are urged to state type of room desired, names of the occupants, expected time of arrival and departure. This information will avoid registration delays and assure them the best available accommodations.

Technical Program

The tentative program, composed of 79 technical sessions sponsored by 22 Professional Divisions and Committees, will be published in the November issue.

A thumbnail sketch of what can be expected follows:

Applied Mechanics: Six sessions; 10 papers on such subjects as critical loading of columns of varying cross section; bending of an elliptical plate by edge loading; comparison of flow and deformation theories of plasticity, and others.

Aviation: Symposium on air-cargo handling; also a luncheon followed by inspection trip to Newark Airport—possibly flights over New York.

Boiler-Water Research: Four papers; hideout of sodium phosphate in high-pressure boilers; sulphite and silicate experience at Springdale Station; treatment of make-up in high-pressure by-product steam plants; and automatic degasser for steam sampling.

Fuels: Seven papers on effect of pressure on combustion of pulverized coal; new underground mining procedures; oil-shale processing; practical applications of the anthratube; symposium of fly-ash utilization; report on Illinois smokeless furnace; and gasification of pulverized coal in vortex reactor.

Gas-Turbine Power Jointly With Other Divisions: Survey of AK closed-cycle gas turbines during 1945–1950; 4000-hp gas-turbine locomotive for passenger service; ceramics in gas turbines; metallurgy of gas-turbine materials, and others.

Hydraulics: Three papers on water diversion in the Nantahala Power System; cavitation tests by the vibratory method; and water hammer in oil lines; and Hydraulic Oldtimers' dinner.

Industrial Instruments and Regulators: Two sessions; four papers on graphical gear-train design; studies in proportional control; automatic temperature control for electrically heated windshields; and automatic machine for analyzing telemetered-missile data.

Machine Design: Three sessions; eight papers on such subjects as antifriction bearings, identifications standards, housings and spindles, maintenance, characteristics of greases, oil lubrication, and others.

Management: Six sessions; symposiums on obligation of management to be competent, to create a better industrial life, control costs, create quality, and improve distribution.

Marine Power: Two papers, vibration of marine-turbine blading and 28,000-ton tanker design.

Power: Four sessions, ten papers on economics of reheat; costs of reheat versus nonreheat for 100-mw units, steam-turbine blading development, testing of long steam-turbine blading; storing and reclaiming coal with earth-moving equipment; evaluation of steam-power-plant losses by means of entropy-balance diagram; and others.

Safety: Three papers on theory of machine guarding; isotopes as tools of engineering; and handling hot atoms.

Wood Industries: Two sessions eight papers on finishing materials for wood products; spray process for wood finishing; finishing of piano cases and fine furniture; holding power of nails; developments in wood cutters; and pumps and hose for forest-fire fighting.

Official Notice

ASME Business Meeting

THE Annual Business Meeting of the members of The American Society of Mechanical Engineers will be held on Monday afternoon, Nov. 28, 1949, at 5:00 p.m. in the Hotel Statler, New York, N. Y., as a part of the Annual Meeting of the Society.

Members are urged to attend.

Twelfth AIME-ASME Joint Fuel Conference to Be Held Oct. 26–27

L. A. Shipman to Receive Percy Nicholls Award

A SYMPOSIUM on dewatering and drying coal, atomic power and its effect on fuel supplies, and problems in the burning of solid fuels will be some of the topics discussed during the 12th Joint Fuels Conference of the Coal Division of the American Institute of Mining and Metallurgical Engineers and the Fuels Division of The American Society of Mechanical Engineers, to be held at French Lick Springs Hotel, French Lick Springs, Ind., Oct. 26–27, 1949.

Participating in the conference will be the Indiana Coal Preparation and Utilization Society which traditionally holds its annual meeting in the fall.

At the banquet on Wednesday, Oct. 26, the conference will honor Larry A. Shipman, Mem. ASME, fuels engineer, Southern Coal and Coke Company, Knoxville, Tenn., for "notable scientific or industrial achievement in the field of solid fuels" by conferring on him the Percy Nicholls Award for 1949. Mr. Shipman is one of the best-informed fuel engineers in America and has contributed much toward better understanding and utilization of coal. As a member on the technical advisory board of Bituminous Coal Research, Inc., he has been influential in the development of more efficient combustion equipment.

The award was established in 1942 by the AIME and ASME. E. G. Bailey, Arno C. Fieldner, and Ralph A. Sherman are among those who have received the award.

The program will consist of three technical sessions at which eight papers will be read. The social program will begin with a luncheon on Wednesday at which Ward F. Davidson, Consolidated Edison Company of New York, Inc., will speak on "Atomic Energy and Fuel Supply." Philip Willkie, member of the Indiana General Assembly, will be the Speaker at the banquet. The final features of the program will be a buffet luncheon on Thursday, and a trip to the Maid Marian strip mine of the Central Indiana Coal Company, 35 miles from French Lick Springs, where visitors will be able to see some of the latest earth-moving machinery and the operation of a coal drier designed by R. G. Bauhman, general superintendent of preparation and construction.

WEDNESDAY, OCTOBER 26

9:00 a. m.

Registration

9:30 a. m.

Welcoming Address: E. R. Price, chairman, Coal Division AIME; manager, Coal Properties, Inland Steel Company, Wheelwright, Ky.

Symposium on Dewatering and Drying Coal:

Moisture Control With Flash Driers, by F. P. Calhoun, Rochester and Pittsburgh Coal Company, Indiana, Pa.

Operating Data for a Verti-Vane Thermal Coal Drier, by Orville R. Lyons, Battelle Memorial Institute, Columbus, Ohio

Coal Drying in Relation to Coal Preparation, by John L. Erisman, Link-Belt Company, Chicago, Ill.

12:15 p. m.

Luncheon

Chairman: Max A. Matthews

Speaker: Ward F. Davidson, research engineer, Consolidated Edison Company of New York, Inc., New York, N. Y.

Subject: Some Design Problems of Nuclear Power Plants

2:00 p. m.

Steam-Generator Design Development as Influenced by Available Fuels and Fuel Quality, by John Van Brunt, Combustion Engineering-Superheater Company, New York, N. Y.

Fuel-Burning Equipment Development for Available Gas, Oil, and Solid Fuels, by R. K. Allen, Babcock and Wilcox Company, New York, N. Y.

7:00 p. m.

Banquet

Toastmaster: M. M. Leighton, chief, Illinois Geological Survey Division, Urbana, Ill.

Speaker: Philip Willkie, Mem. Indiana General Assembly. Presentation of Percy Nicholls Award for 1949 to Larry A. Shipman

THURSDAY, OCTOBER 27

9:00 a. m.

Some Factors Influencing the Froth Flotation of Coarse Coal Particles, by R. E. Zimmerman and S. C. Sun, Pennsylvania State College, State College, Pa.

Laboratory Control in Coal-Washing and Drying Plants, by J. J. Merle and R. A. Mullins, Ayrshire Collieries Corporation, Indianapolis, Ind.

The Use of Ignition Baffles With Single-Retort Stokers, by T. C. Spicer, R. J. Grace, and C. C. Wright, Pennsylvania State College, State College, Pa.

11:00 a. m.

Inspection Trip

Central Indiana Coal Company's Maid Marian Coal Mine. Lunch will be served en route.

12:30 p. m.

Buffet Luncheon

Role of ASME Professional Divisions in the Life of the Society[1]

THE detailed professional interests of our 28,000 members in the field of mechanical engineering are greatly diversified. Notwithstanding this, it is really remarkable that these members have subdivided themselves as results of natural causes and effects into but twenty professional interest organizations or Divisions.

Large numbers of members are now affiliated with most of these Divisions and membership affiliations with all of the divisions is growing. This attests the approbation by the Society membership of the creditable job being done by all of you who help to carry on the work of administering the activities of the Professional Divisions.

Executive Committees

Council vests official leadership of each division in five-man executive committees. Each committee member serves five years in rotation, thus a new member joins each committee yearly. This tends to provide continuity and the proper indoctrination of newcomers. Each executive committee yearly appoints various subcommittees and perhaps affiliate groups to serve with the committee itself.

[1] Talk by W. L. H. Doyle, chairman, ASME Professional Divisions Committee, 1947–1948, given at a conference held during the 1948 Annual Meeting to discuss the subject "Better Professional Divisions for a Better Society." For similar discussions of ASME Board on Technology, see page 187, February, 1949, issue; ASME Research activities, page 277, March, 1949, issue; ASME publications, page 626, July, 1949, issue.

It is from these appointees that the newcomers to the various executive committees are generally chosen. Since successor Divisional leaders come principally from these sources, it is doubly important to include among the yearly appointees not only recognized leaders in the field of the interests of the Division, but also newcomers—men of experience who are gaining recognition and younger engineers who are starting their career in the field of the Division. These present-day leaders and these newcomers, properly selected, add enthusiasm and freshness of viewpoint. Thus the yearly routine appointment of divisional workers, if properly executed, helps to vitalize the division and is among the important responsibilities resting on all executive committees.

Prime Responsibility

Under the present scheme of organization the Society looks to our Professional Divisions as the primary agency for motivating the flow of technical intercourse among its members. Viewed in this light, the quality of the technical papers rather than the mere numbers of papers and of technical sessions sponsored by the division is the proper basis upon which to weigh the relative usefulness of a division in the direction of this important objective. Managerial problems are involved in procurement of high-quality papers, inducement of all authors to make creditable presentations of their papers, in the development of well organized technical sessions where the value of good papers is enhanced by well prepared discussions procured from competent authorities, and in the procurement of capable chair-

men who motivate good open discussions, and add much of value to the presentations. Involved here are problems challenging the best efforts of all those who help to administer this important phase of Division activities. As we clarify our sights in this general direction, among the rest, the overload on the Society's publication facilities and the present demand for unduly large numbers of technical sessions will naturally be reduced. As a result our Society, through its available publications and meetings facilities, will be in an improved position to meet the demands of the membership for high-quality technical intercourse as indicated by technical papers presented at the meetings and published for distribution to the membership.

Volunteer Effort

The work of conducting the affairs of our twenty Professional Divisions is mainly carried on by volunteers. Because of this the effective accomplishments resulting from this management are all the more striking. As the Society has grown, the magnitude of this managerial work has increased. Based on observations in the work of the Divisions during the past several years, it has become evident that we must soon add to our Headquarter's staff, secretarial help which will be devoted entirely to the job of carrying on much of the routine work now resting on the shoulders of volunteer workers. Actually, we have some Headquarters help now; however, in terms of the Professional Division's needs this is far too limited. We need staff personnel to attend meetings of our Executive Committees and to help in the development and execution of numerous routine activities.

Much of the time of the one staff man now assigned to help in the work of the divisions is consumed in programing meetings. This is important and the results of his efforts are very creditable.

We are fortunate in having a man of his caliber working with us. But, others equally capable are also needed to help our Divisional executives and thus permit them to devote more of their available volunteer time and talents to the broader managerial phases of the job of operating successful divisions for the benefit of the membership.

Heavy Personal Expense

Because of the highly specialized nature of the technical interests of some of our Divisions, it has been found advantageous and, in some cases, essential to include among the membership of the executive committees of some of the Divisions, individuals who are enlisted from academic, nonprofit laboratory, and other similar occupations. From this group during the past two or three years has come the request that some arrangements be developed whereby allowances can be defrayed by the Society to meet some of the costs incurred when attending executive committee meetings. It would appear advantageous to provide expense allowances under properly limited conditions so as to live within the Society's income and yet implement the broadest possible technical representation among the management of the Divisions.

Our committee has therefore followed through on this request and has proposed a procedure which it considers workable.

Deters Fragmentation

The successful workings of the Professional Divisions' scheme provide factors which are important aids in combating trends in the direction of membership breakaways for forming other professional organizations. Early in the development of the Division scheme of organization some breakaways occurred. It is significant that in later years we have had no breakaways. This is another evidence of membership approbation of the creditable job being done by the administration of the divisions. Maybe some breakaways will occur in the future. This can be avoided by wise leadership not only from the administration of the Divisions, but also from Council and the officers of the Society. Needed is leadership which senses the influences of new technical interests and significant changes in existing interests. As leaders in our respective capacities we must ever be alert to these changes and diligent in our efforts to provide constructive means for keeping the various forms of technical intercourse among our members abreast of the times. As one step in this direction it is proposed that members of administration of the Professional Divisions hold an annual get-together. The program of these annual meetings would be concerned primarily with the broader problems and operating activities of the Divisions. Meetings such as these would naturally facilitate the general development of a better understanding of our mutual problems and as a result we could expect constructive results.

Bold Ideas Needed

It is well to remind ourselves of one important phase of the work of the Professional Divisions which has been inadequately developed. Basically, our Professional Divisions, in so far as meetings are concerned, provide technical intercourse for those specialists who are able to attend the regular national Society meetings and the Divisional conferences. Society-wise, this attendance represents a relatively small percentage of the total membership.

Our Sections hold a considerable number of meetings throughout the country. The membership at large, it may be safe to say, is not satisfied with the technical quality generally typifying Sectional meetings. This reaction, also prevails in other large technical societies. The Professional Divisions of the Society could add value to the services they are now rendering the membership if procedures could be worked out whereby they could help to provide a broader coverage for satisfying the professional interests of our membership at large. This is an important problem. The practical solution is not yet in sight.

A better Society, better than the one we now know, challenges the best efforts of the host of enthusiasts who carry on the various activities of the Society including those of the Professional Divisions. To attain further success in the work of the Divisions our collective managerial efforts must continue effective and our outlook broad and ever focused on new horizons.

ASME Calendar

of Coming Events

Oct. 26–27, 1949
ASME Fuels Division Conference, French Lick Springs Hotel, French Lick Springs, Ind.
(Final date for submitting papers was June 1, 1949)

Nov. 27–Dec. 2
ASME Annual Meeting, Hotel Statler, New York, N. Y.
(Final date for submitting papers was Aug. 1, 1949)

April 12–14, 1950
ASME Spring Meeting, Hotel Statler, Washington, D. C.
(Final date for submitting papers—Dec. 1, 1949)

April 24–26
ASME Process Industries Division Conference, William Penn Hotel, Pittsburgh, Pa.
(Final date for submitting papers—Dec. 1, 1949)

June 12–16
ASME Oil and Gas Power Division Conference, Lord Baltimore Hotel, Baltimore, Md.
(Final date for submitting papers—Feb. 1, 1950)

June 12–16
ASME Fourth National Materials Handling Exposition and Conference, International Amphitheater, Chicago, Ill.
(Final date for submitting papers—Feb. 1, 1950)

June 19–23
ASME Semi-Annual Meeting, Hotel Statler, St. Louis, Mo.
(Final date for submitting papers—Feb. 1, 1950)

June 22–24
ASME Applied Mechanics Division Conference, Purdue University, Lafayette, Ind.
(Final date for submitting papers—Feb. 1, 1950)

Sept. 11–15
ASME Instruments and Regulators Division Conference, Municipal Auditorium, Buffalo, N. Y.
(Final date for submitting papers—May 1, 1950)

Sept. 25–27
Petroleum Mechanical Engineering Conference, Hotel Roosevelt, New Orleans, La.
(Final date for submitting papers—May 1, 1950)

(For Meetings of Other Societies see page 874)

ASME Junior Forum

Compiled and Edited by a Committee of Junior Members, Robert L. Reich, Chairman

Forum Welcomes 1949 Juniors

FOR the third successive October, the National Junior Committee of The American Society of Mechanical Engineers inaugurates its own section in Mechanical Engineering to provide a forum in which younger members of the Society can explore and develop the means by which the ASME can better serve them, and in turn benefit more directly from their ideas and enthusiasm.

The National Junior Committee was organized in 1947 at the suggestion of President Eugene W. O'Brien, who during his administration did much to advance the professional interests of junior members. Since then the Committee has been meeting regularly in the Headquarters Building, New York, N. Y., and annually during the Annual Meetings.

At its second meeting in July, 1947, plans for the forum were formulated and an editorial committee composed of juniors from the Metropolitan Section appointed to solicit material from juniors in other sections and to report on the activities of the National Junior Committee. The forum has published letters from juniors, reports of junior activities, short articles or abstracts of articles on the general subject of professional development, and has reviewed books of special interest to young engineers. This year more of the same can be expected.

Welcome to 1949 Juniors

The National Junior Committee particularly welcomes into the professional ASME family juniors who have left the campus in 1949. These men are by this time well established in new communities and have already weathered the first experiences of life in industry. If they have not already done so, October is the time to search out the chairman of the local ASME Section and to introduce themselves to local ASME members. Opportunities lie in wait for them at local Section meetings, as well as plenty of work of the type that will provide a valuable insight into how engineers work and live away from their jobs.

In all likelihood they have already been buttonholed by the 1948 class of juniors and have had a worthy welcome into the local ASME family; but if not, the time is ripe for initiative. They should go to the October meetings, even if they have to start out alone. Rich associations, perhaps lifetime comradeship await them, for the 1949 class is large in number and comes from all the engineering campuses of the country. Some old hand will meet them at the door and introduce them around, but if not, they should not hesitate to stop the first man they see, young or old, introduce themselves, and offer to help in Section activities in any way possible.

Now is the time to appreciate a simple truth, that the path to success in engineering does not run in one direction but in many. Two of them are well worn by those who have gone before. One leads to success through achievement and recognition in the narrow field defined by the job and the specific company which chance or preference determines early in an engineering career. The other leads to the top through achievement in the broader field of engineering opportunity created by the activities of a professional society. Many an engineer at the dead end of opportunity on the engineering staff of his own company through no fault of his own, has found new vistas of service opened to him by his professional colleagues in other companies who have come to respect his abilities because of his participation in professional-society work.

Some juniors perhaps find themselves in communities remote from large industrial centers, where few ASME members reside, and where no local section has been established. The forum particularly bids them welcome. When they feel the need to talk engineering, they are urged to sit down and write a breezy letter to the forum, or to some member of the National Junior Committee. Such letters will be warmly received and will be answered in kind. If they seek answers, want suggestions or help, the forum is prepared to comply.

D. E. Jahncke is chairman of the National Junior Committee.

What Is An Engineer? [1]

FIRST, what do we mean by an engineer? There are many definitions, some of them quite sharply limited in scope. For instance, in New York and in many other states no one legally may call himself an engineer unless he has been licensed by the state after scrutiny of his experience and after two examinations four years apart, in one of which the theory of structures plays a considerable part. In these states every blueprint prepared for a client must carry the signature of a licensed engineer. On the other hand, in the idiom of the Bell Laboratories in New York City, an engineer is a research and development man. Often he originally was trained as a physicist, or even as a mathematician, and his work is often largely what would be called pure science in any other environment. And then there are, in the United States, many firms specializing in industrial or market surveys, or acting as consultants on industrial organization and management, that carry on their letterheads the proud word "engineers."

Diversity of Usage of Term

In the face of all this diversity of usage, I personally like to give to the word "engineer" a very broad, inclusive meaning, making no distinction between engineers and pure scientists on the one hand, or between engineers and a large group of industrialists on the other hand. In my vocabulary, any man who has adequate technical training in any part of the great field of the natural, as distinguished from the biological and the social science, is a member of our family. More particularly, any graduate of a school of engineering is and remains one of us, no matter into what kind of activity the development of his career may lead him.

This is, I admit, a pretty broad definition. Under it, to cite some examples chiefly from among the alumni of the Stevens Institute of Technology, there are engineers who are practicing law, lots of them, especially of course but by no means exclusively, in the field of patent law. There are engineers practicing medicine. One of them came to Stevens with his mind already set on a medical career before he entered; he is now head of the department of opthalmology in one of the great New York medical-school hospitals. Another Stevens graduate, a dentist, is a recognized authority in his specialty, which is bridge work. No, I am not feeling my way toward a play on words. He claims that building a bridge across a river 50-feet wide and building one across a quarter-inch gap in a mouth are one and the same problem. In both instances, one deals with loads and bending moments and abutments and thrusts against them. The only real difference seems to be that in the case of the 50-foot bridge one usually can count on one's abutments being fairly well fixed in position.

Wide Application of Training

There are also engineers in banks, in investment houses, and insurance companies. There are engineers working on various phases of the social sciences, particularly economics, and also sociology, is applied psychology on the one hand, and labor relations on the other, are indeed branches of sociology. There are of course thousands of engineers in industry, both in staff and in line positions. Indeed, this field takes well over two thirds of the engineering graduates, not only at Stevens, but throughout the United States. There are engineers who are ministers of the gospel. One of the most distingushed of Stevens alumni once said that he felt that his engineering

[1] Excerpt from "The Engineer's Part," by Harvey N. Davis, Hon. Mem. ASME, president, Stevens Institute of Technology, Hoboken, N. J. First Wallberg Lecture, delivered on Jan. 27, 1949, at the University of Toronto, Toronto, Ontario, Can.

training had done him a world of good in his work as an Episcopal clergyman. There are also engineers who are professional artists. Calder, with his well-known "mobiles," and the late Eugene L. Vail, whose paintings are hanging in half a dozen leading art galleries in the United States, are both on the Stevens alumni list, and Doctor Krapetoff, formerly a professor of electrical engineering at Cornell University, who died recently, was a distinguished professional pianist. I even might add that Rube Goldberg, the cartoonist, and Arthur Murray, the dancing teacher, are both graduates, not of Stevens, but of other American engineering schools.

Engineering Is a Point of View

My broad definition of an engineer is very inclusive. In my view every one of these men has done a different kind of job in his career from what he would have done in that same career if his college training had not been in engineering. I do not mean that these men necessarily have done better jobs than their arts-college trained colleagues in similar careers, though most of them have done distinctly well. What I do mean is that, because of their engineering training, each one of them has brought a somewhat different, a somewhat unique point of view to his work that has played a useful part in the general thinking in his field. If that be so, why should we disown him as having abandoned engineering? As someone once said of the city of Boston, engineering is not a particular area in the field of human endeavor; it is rather a point of view, and anyone who once has had it keeps it no matter where his work lies.

Twelve Regional Student Branch Conferences Close Successful 1948-1949 Season

TWENTY-FIVE hundred student members of The American Society of Mechanical Engineers, representing most of the 127 student branches of the Society, attended 12 Regional Student Branch Conferences held in central points in all regions to make the meetings accessible to as many students as possible.

The conferences reflected the keen interest and earnest enthusiasm of the students toward their chosen profession and presented an opportunity for lively discussions of methods which could best be employed to promote a greater interest in professional development and a more active interest in student participation in local student-branch activities on their respective campuses.

The prize papers were of high quality and the local hosts had made their arrangements well with an eye to dignified sessions as a worthy setting for the presentation of these technical papers. Also for the enjoyment of those attending the conferences, educational inspection trips were made available by local industry and were supplied with competent guides. Good-fellowship was the assured keynote at the banquets, luncheons, and entertainment provided between meetings. Many of the conferences were addressed by members of ASME, from industry and the profession, and the profession and civic leaders of the vicinity.

The serious attitude of the students and those in charge of the conferences accounts for much of the success which resulted. The Sessions resembled the ASME Annual Meeting, on a smaller scale, and may augur well what may be anticipated for the future when these men will join the regular membership of the Society and will contribute their professional opinions.

The issues that received considerable attention across the country dealt with such matters as what could be done to stir up student participation in local student branches and to improve attendance at meetings. Some worth-while suggestions were made toward the manner in which to best improve the meetings; for instance, getting speakers from the profession and allied industry residing locally, or inviting speakers from not too great distances to make talks on topics of current interest or basic principles. The showing of films or illustrated talks seems to have been popular. There were some who felt that the lack of attendance might possibly be remedied if some qualification such as scholarship was required before a student membership was granted.

The new plan for transferring student members to the grade of junior membership was discussed and it was agreed that it is up to the honorary chairman to see that the transfer forms are filled out in ample time so that the transfer can be effected before the student is graduated. The question of increasing the mileage allowance to attend conventions over the present amount was taken up. It was suggested that the election of new officers take place early enough in the preceding semester so that when the time came for the new officers to take over, they would be fully cognizant of their duties and the best way to execute them.

The list of prize-winning papers and authors appears on the following pages.

Connecticut Is Host to New Englanders

More than 250 students from 16 colleges and universities in New England attended the Region I conference, at the University of Connecticut, Storrs, Conn. The program started with a field trip through the operation and testing department of the Pratt and Whitney Aircraft Division of the United Aircraft Corporation, East Hartford, Conn. In addition to the two dinners and the presentation of the technical papers, a magic show was performed for the pleasure of the group. The prizes were presented by James M. Todd, President, ASME, who also made an address.

Region II Meets in Brooklyn

The evening session of the conference which was held at Polytechnic Institute of Brooklyn, heard Col. Crosby Field, Fellow ASME, president, Flakice Corporation, Brooklyn, N. Y., speak on "Living the Engineering Life." In his talk he strongly advocated small business and ownership of production capital as the ultimate goal for every young man. "Real security," he asserted, "is to be found only in the dynamic stability which ownership affords."

A guided tour was conducted through the mechanical-engineering laboratories and the visitors were shown demonstrations of x-ray apparatus, inductor furnaces, vibration conveyers, and materials-testing equipment. A social hour followed in which Steve Einig did a monologue of impersonations and the Glee Club entertained.

Region III Goes to Washington

An item of unusual interest was displayed at the technical session. It was a photostatic copy of the register of the first Annual Meeting of the ASME held in New York, N. Y., on Nov. 5, 1880. This copy was presented to George Washington University by trustee Henry Parsons Erwin, Mem. ASME, whose grandfather, Henry Parsons, was one of the signers of the original register. The conference was held at George Washington University, Washington, D. C., and 300 attended.

Alabama Is Host to Region IV

More than 300 students came to the conference held in Birmingham, Ala. With the University of Alabama, and Alabama Polytechnic Institute, the Birmingham Section served as joint hosts. There were two interesting inspection tours; one to the plant of the Tennessee Coal, Iron and Railroad Company, and the other to the plants of Local Cast Iron Pressure Pipe Manufacturers. Dr. J. L. Brakefield, of the Birmingham Chamber of Commerce, told the future engineers that there is the greatest future for them in the South.

Region VI Holds Two Conferences

The Southern Tier met at Washington University, St. Louis, Mo., and about 225 students attended. There were five inspection trips to nearby industrial plants and laboratories. At the annual banquet David Larkin, Fellow ASME, spoke on "Civic Responsibilities of Engineers." Forrest Nagler, vice-president, ASME Region VI, made the awards at the Award banquet.

The Northern Tier was guest of Marquette University, Milwaukee, Wis. and was host to 300 students Mr. Nagler also presented the awards at this conference and made the principal speech at the convention banquet. The subject of his talk was, "Archery, An Engineering View." Three field trips were arranged for the delegates. They had the opportunity to inspect the plants of Allis-Chalmers Manufacturing Company, the A. O. Smith Corporation, and the Nordberg Manufacturing Company. The three companies made every effort to make the trips enjoyable and informative.

Thirteenth Conference for Pacific Northwest

The thirteenth annual conference of the Pacific Northwest, Region VII, attracted 264

1949 ASME Regional Student Conference Prize Winners

REGION I UNIVERSITY OF CONNECTICUT, STORRS, CONN., APRIL 29-30, 1949

Attendance: 257 — Papers Presented: 12

Prize	*Recipient*	*Title of Paper*	*College*
First	George D. Lewis	Natural Limitations on Space Travel	University of Connecticut
Second	Edward L. Kilsby, Jr.	Boot-Strap Gas Turbine	Brown University
Third	Delbert M. Bressette	Window Sash Manufacturing-Hobby to Business	University of Vermont
Fourth	Howard Kaltbaum	Rockets	Cornell University
Old Guard	Robert L. Brown	Combustion-Chamber Design in Spark-Ignition Engines	University of Rochester

REGION II POLYTECHNIC INSTITUTE OF BROOKLYN, BROOKLYN, N. Y. APRIL 30, 1949

Attendance: 125 — Papers Presented: 7

Prize	*Recipient*	*Title of Paper*	*College*
First	Joseph Singer	The Influence of Sand Control on Foundry Economy	Polytechnic Institute of Brooklyn Evening School
Second	Edward L. Fischer	An Arc-Welded Automobile Engine Positioner	Stevens Institute of Technology
Third	David Young	A Test Setup for Simulating Operating Conditions of Automobile Engines	Cooper Union School of Engineering
Fourth	Stephen Kowalski	Engineering as a Profession	Polytechnic Institute of Brooklyn
Old Guard	Irving Kleinman	Radiant Heating Versus Convection Heating	College of the City of New York

REGION III GEORGE WASHINGTON UNIVERSITY, WASHINGTON, D. C., APRIL 1-2, 1949

Attendance: 300 — Papers Presented: 15

Prize	*Recipient*	*Title of Paper*	*College*
First	William C. Etherington	Design of an Unsymmetrical Tailless Model Airplane	Syracuse University
Second	Stephen Mucha	Three-Dimensional Photography	Swarthmore College
Third	Richard J. Seymour	Determination of Ship Resistance Through Water	U. S. Naval Academy Midshipman School
Fourth	Wayne H. Fenton	A Fluid Polariscope	Pennsylvania State College
Old Guard	Michael Singer	Scientific Management in Industry Today	Princeton University

REGION IV BIRMINGHAM, ALA., APRIL 4, 5, 1949
Hosts: Birmingham Section
University of Alabama
Alabama Polytechnic Institute

Attendance: 314 — Papers Presented: 13

Prize	*Recipient*	*Title of Paper*	*College*
First	Thomas Ross Ballew	Automatic Transmission	Vanderbilt University
Second	George Hamner	Atomic Power Plants	Alabama Polytechnic Institute
Third	Louis M. Newton	Modern Steam Locomotives	University of Tennessee
Fourth	Grady W. Bowers	Photoelasticity an Important Design Tool	North Carolina State College
Fifth	Norman P. Wagner	Radiant Heating	Clemson Agricultural College
Old Guard	Hubert Bullock	Engineering and Aircraft	University of Alabama

REGION V, OHIO STATE UNIVERSITY, COLUMBUS, OHIO, APRIL 25-26, 1949

Attendance: 137 — Papers Presented: 11

Prize	*Recipient*	*Title of Paper*	*College*
First	Eli Solop	The Andal Rubber Thread Process	University of Akron
Second	William L. Thomson, Jr.	An Investigation of Water Injection in an Automobile Engine	Carnegie Institute of Technology
Third	Kenneth E. Coburn	The Rotary-Vane-Type Internal-Combustion Engine	University of Detroit
Fourth	Russell K. Annis, Jr.	Wear on Cast-Iron Piston Rings	Ohio State University
Old Guard	Vincent P. Burns	Transfer Machine Tools	University of Michigan

REGION VI, SOUTHERN TIER, WASHINGTON UNIVERSITY, ST. LOUIS, MO., APRIL 21-22, 1949

Attendance: 225 — Papers Presented: 9

Prize	*Recipient*	*Title of Paper*	*College*
First	Raymond Hudackek	The Rate of Corrosion on the Internal Surface of Pipes	State University of Iowa
Second	Richard W. Bartsch	The Design and Construction of a Low-Cost Gas-Fired Domestic Heating Unit	University of Kentucky
Third	George A. Neff	The Power Lawn Mower	Washington University
Old Guard	Donald L. Kraft	Where to Now?	University of Missouri
Fifth	James M. Ballard	Radiant Heating	University of Louisville

REGION VI, NORTHERN TIER, MARQUETTE UNIVERSITY, MILWAUKEE, WIS., MAY 2-3, 1949

Attendance: 300 — Papers Presented: 11

Prize	*Recipient*	*Title of Paper*	*College*
First	William N. Blatt	Gas Flow Dynamics in a Two-Stroke-Cycle Engine	University of Minnesota
Second	George Avalon	Pivot-Bearing Design, Research, and Application to Instrumentation	Northwestern University
Third	Daniel K. Sewell	An Engineer and a Little More	North Dakota Agricultural College

Fourth	Jerrold Peace	The Design and Fabrication of an Arc-Welded Drawing-Table Base	Iowa State College
Old Guard	Richard Abowd	What Difference the Plug Makes	University of Notre Dame

REGION VII, PACIFIC NORTHWEST, UNIVERSITY OF WASHINGTON, SEATTLE, WASH., MAY 4–7, 1949

Attendance: 264 Papers Presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Vernon L. McCloskey	Rotary Engine	University of Washington
Second	George Plant	Groundwater Development	University of British Columbia
Third	Dunc McEwen	The Hydromatic Drive	University of British Columbia
Fourth	Norman S. Johnson	Photoelasticity	University of Idaho
Old Guard	Carlos DeGrief	Cam Engine	University of Washington

REGION VII, PACIFIC SOUTHWEST, UNIVERSITY OF NEVADA, RENO, NEV., APRIL 29-30, 1949

Attendance: 62 Papers Presented: 13

Prize	*Recipient*	*Title of Paper*	*College*
First	James T. Kenney	Improved Methods in Measuring Sewage Flow	California Institute of Technology
Second	Richard Bauer	Redesign of an Ice-Vending Machine	University of Santa Clara
Third	Jerry DeCamp	The Free-Piston Diesel System—The Performance of a Junker's Unit	Stanford University
Fourth	Edwin A. Pecker	The Industrialized House	University of California
Old Guard	Donald C. Peabody	Ballast Determination From a Model Sailboat	University of California

REGION VIII, SOUTHERN TIER, TEXAS TECHNOLOGICAL COLLEGE, LUBBOCK, TEXAS, APRIL 1-2, 1949

Attendance: 122 Papers Presented: 11

Prize	*Recipient*	*Title of Paper*	*College*
First	Lawrence S. Johnson	Investigation of W-329	Texas Technological College
Second	John B. Gambrell	Summer Air Conditioning for Automobiles	University of Texas
Third	Beldon A. Peters	Comparison of Rifle Cartridges	Texas Technological College
Fourth and Old Guard	Raphael Silberman	Optimum Design of Aircraft Wings	Rice Institute

REGION VIII, NORTHERN TIER, UNIVERSITY OF KANSAS, LAWRENCE, KAN., MAY 5–7, 1949

Attendance: 250 Papers Presented: 12

Prize	*Recipient*	*Title of Paper*	*College*
Tie for First Place (1st and 2nd prize divided)	Jack C. Williams	Diesel-Electric Locomotive	Oklahoma A&M College
	Keith B. Kittle	Die-Casting Design	University of Nebraska
Third	Ralph H. Creighton	Crank-Case Lubrication by Laboratory Engine Testing	University of Kansas
Fourth	Si Chiu Lou	Electrical Indicators	University of Arkansas
Old Guard	William B. Murray	Corrosion Fatigue of Metals	University of Oklahoma

REGION VIII, ROCKY MOUNTAIN, UNIVERSITY OF DENVER, DENVER, COLO., APRIL 8-9, 1949

Attendance: 151 Papers Presented: 13

Prize	*Recipient*	*Title of Paper*	*College*
First	William Snyder	Jet Propulsion	New Mexico College of A&M Arts
Second	Donald MacKinlay	Nuclear Fission Applied to Power Generation	Colorado School of Mines
Third	Marshall Gillispie	Gasoline Versus Diesel for Industrial Power	Colorado A&M College
Old Guard	Frans E. Lusch	Practical Patent Procedure	University of Wyoming
Fifth	Willis Groth	Inert-Arc Spot Welding	University of New Mexico
Sixth	Victor Cotz	Coal for the Production of Heat and Power	University of Denver

visitors to the University of Washington, Seattle, Wash. Some had great distances to travel but it was worth it. The technical sessions were a huge success. At the banquet, J. Calvin Brown, vice-president, ASME, Region VII, gave an interesting talk on "Perpetual Motion," after which he distributed the student prizes. The field trips were arranged to see the Pacific Car and Foundry, Bethlehem Pacific Coast Steel Corporation, Kenworth Motor Truck Company, Boeing Airplane Company, and the Bremerton Navy Yard.

The eleventh annual meeting of the Pacific Southwest Group, Region VII, was held at the University of Nevada, in Reno, Nev., and sixty-two attended. Prof. S. F. Duncan chairman of the committee on student branches, Region VII, of the University of Southern California, served as the chairman during the discussions, and awarded the prizes. The inspection trip covered the Virginia City Mines.

Region VIII Holds Three Conferences

The Southern Tier conference of Region VIII was held at Texas Technological College, Lubbock, Texas. Aside from the ASME prize money, merchandise prizes were awarded. Among the 122 students who were greeted, the Louisiana Polytechnic Institute was congratulated on their newly formed ASME student branch. Carl J. Eckhardt, Regional vice-president, was the principal speaker at the first banquet. The title of his address was "Engineering Success in a Changing World." The speaker at the award banquet was R. N. Dyer. The subject of his talk was "Power-Plant Operation and General-Utility Engineering." The prizes were awarded to the student speakers by Prof. L. J. Powers, Texas Technological College.

The Northern Tier, Region VIII conference was held at the University of Kansas, Lawrence, Kan., and there were 250 in attendance. The high light of the banquet was an unusually inspiring address by Prof. Carl J. Eckhardt, vice-president Region VIII, ASME. He awarded the prizes at the Saturday noon luncheon. His kindly words of praise and encouragement on behalf of ASME were most timely and well received.

The Rocky Mountain Student Conference of Region VIII met at the University of Denver and Colorado School of Mines; 151 student members attended. Inspection trips were arranged to see the Public Service Company, Lacombe Plant, Valley Road, Denver, Colo., and The Metallurgical Plant, Golden, Colo. Professor Eckhardt addressed the group at the annual banquet.

Keep Your ASME Records Up to Date

HEADQUARTERS depends on its master membership file for answers to hundreds of inquiries daily pertaining to its members. All other Society records and files are kept up to date through changes processed through it. The listings in future ASME Membership Lists will be taken directly from the master file. It is important to you that it lists your latest mailing address and your current business connection.

The mailing form on this page is published for your convenience. You are urged to use it in reporting recent changes.

Your mailing address is important to Headquarters. Please check whether you want your mail sent to home or office address.

ASME Master-File Information

Please Print **Check Mailing Address**

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Notify Headquarters Promptly of Changes

ASME Sections

Coming Meetings

Chattanooga: October 14. Chattanooga Golf and Country Club. Regular monthly section meeting.

Metropolitan: October 10. Engineers' Forum, Room 1101[1] at 7:30 p.m. Subject: Vacation Adventures in Review, by H. R. Kessler.

October 13. Woman's Auxiliary. Membership Luncheon, Engineering Woman's Club, 2 Fifth Avenue, at 12:30 p.m.

October 13. Management Conference, Hotel New Yorker. Subject: Management—a Trusteeship. 9:30 a.m. Panel Discussion, Chairman, J. Keith Louden. 12:30 p.m. Luncheon. Address by Dr. J. M. Juran. 2:30 p.m. Round Table Discussions.

October 13. Metropolitan Section Night. Fifth Avenue Hotel, New York, N. Y. Cocktails 6 p.m. to 7 p.m. Dinner 7 p.m. followed by a talk by Dr. Lillian M. Gilbreth. Subject: Management Problems in the Home.

October 20. Junior Group, Room 1101[1] at 7:30 p.m. Subject: A Brief Introduction to Servomechanisms, by H. Moak.

October 25. New Jersey Division. Plant visit to General Motors Corp., Linden, N. J. Two tours; one leaving main gate at 9:15 a.m., second, leaving main gate at 1:15 p.m.

October 27. Engineers' Forum, Room 501[1] at 7:30 p.m. Subject: Exporting American Know-How—What It Means to World Peace, by Dr. J. V. N. Dorr, and Mrs. Wallace Clark.

Oct. 28. Joint Meeting, ASME Metropolitan Section and ASTM New York Section. Room 502,[1] at 7:30 p.m. Subject: Future of Nuclear Power, by A. L. Baker, and Isotopes in Industry, by J. R. Dunning.

Southern California: October 26. Seminar on Hydraulic and Pneumatic Systems, sponsored by ASME Hydraulics, Applied Mechanics, Machine Design, Instruments and Regulators, and Aviation Divisions; ASCE, IAS, SAE, ARS. Chairman, H. Field, Jr.; assistant chairman, J. S. Newton. 7:30 p.m. at California Institute of Technology, Pasadena. Speaker: G. P. Sutton. Subject: Hydraulics of Liquid-Propellant Rocket-Motor Systems.

Washington, D. C.: October 27. Student Smoker. Student members from Catholic University, George Washington University, and the University of Maryland will join with the section members and juniors at this annual affair.

Youngstown: October 13. Trinity M.E. Church Hall. Discussion meeting—Power. Speaker and subject to be selected by Power subcommittee.

Oct. 27. Discussion Meeting—Management. Speaker and subject to be selected by Management subcommittee.

Detroit: October 11. ASME Night. Dinner meeting at Rackham Educational Memorial Building. Speaker, J. M. Todd, President, ASME.

Philadelphia: October 4. Professional Division Meeting. Towne School, University of Pennsylvania, 8 p.m. Speaker: L. M. Sandell. Subject: High-Speed Motion Picture in Industry.

October 10. Men's Smoker—Football Night, 7:30 p.m., Engineers' Club, 1317 Spruce St.

October 12. Junior Meeting. Engineers' Club, 7:30 p.m. Speaker: F. W. Kearcher. Subject: Materials Handling.

October 25. Joint Meeting with AIEE. Edison Building, Ninth and Sansom Sts. Speakers: H. Weisberg and M. D. Hooven. Subject: Sewaren Generating Station.

[1] Engineering Societies Building, New York, N. Y.

Section Activities

REPORTS of the following ASME Section Meetings were received recently at Headquarters:

Anthracite-Lehigh Valley: Sept. 23. Speaker: Olin H. Phillips. Subject: Talgo—American Car and Foundry Co., Mystery Train.

Chicago: Sept. 20. Speaker: Arthur Lazarus. Subject: The Status and Responsibilities of the Chief Engineer.

Rocky Mountain: Sept. 9. Speaker: D. Chalmers. Subject: Rubber Research.

Western Massachusetts: Sept. 20. Inspection trip, Bigelow-Sanford Carpet Co., Inc., 2:30 p.m. Dinner Meeting. Speaker: E. I. Petersen. Subject: The Engineer's Contribution to a Higher Standard of Living.

Youngstown: Sept. 8. Speaker: J. E. Savely. Subject: Lake Erie-Ohio River Conveyer Belt.

Candidates for Membership and Transfer in the ASME

THE application of each of the candidates listed below is to be voted on after Oct. 25, 1949, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

R = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

Amburgey, Eugene, Campbellsville, Ky.

Andrews, William F., Jackson Heights, L. I. N. Y.

AYRE, ROBERT STEVENSON, Stanford, Calif.
BAIRD, RAYMOND C., Los Angeles, Calif.
BECHERT, ROBERT CHARLES, Stamford, Conn.
BELLAGAMBA, EUGENE M., Lackawanna, N. Y.
BERRY, W. HENRY, Point Fortin, Trinidad, B.W.I.
BOISSONAULT, F. L., Sacramento, Calif.
BOYD, RAYMOND T., Brooklyn, N. Y.
BRONCKHURST, P. F., San Mateo, Calif.
BROOKS, WILLIAM B., New Orleans, La.
CAPREZ, RETO, Schenectady, N. Y.
CHANEY, R., Melbourne, Australia
CHOU, JAMES C. S., Atlanta, Ga.
CLARK, CHARLES T., Los Angeles, Calif.
COLE, EDGAR BOYD, Ogden, Utah
COLGIN, HARVEY LEE, Richmond, Va.
CRIPPEN, GLENN E., Montebello, Calif.
CRIST, WM. F., JR., Mount Holly, N. C.
CUNDIFF, ROBERT M., Cincinnati, Ohio
DELPHOS, PHILLIP R., Worcester, Mass.
DRAIN, WILLIAM N., JR., Oreland, Pa.
DUNDAS, WILLIAM A., JR., La Grange Park, Ill.
EAVES, HAYDEN CRONIN, JR., Alhambra, Calif.
EDELMAN, H., Chicago, Ill.
EILERING, JOHN G., Park Ridge, Ill.
GALE, RONALD, Laconia, N. H.
GASCHE, FRED, Erie, Pa.
GOES, MILTON LUIZ BASTOS, Rio de Janeiro, Brazil
HAINES, JOHN F., Dayton, Ohio
HALLIWELL, W. F., Stamford, Lincolnshire, England
HANNA, JOHN C., Evanston, Ill. (Rt)
HODGE, PHILIP G., JR., Los Angeles, Calif.
HOOPER, K. E., Winnetka, Ill.
HUFF, MELVIN E., Tarrytown, N. Y.
JEFFERS, DALE O., Beloit, Wis.
JONAS, G. ARTHUR, Miami, Fla.
KELSEY, DON W., Ann Arbor, Mich.
KIMSEY, WILLIAM LEWIS, Scottsdale, Ariz.
KRAEGER, VINCENT S., Wenham, Mass.
LAIGAARD, NIELS H., Cedar Falls, Iowa
LA MASTER, CHELSEY C., Berkeley City, Mo.
LOOK, EDWARD C., JR., Barrington, Ill.
MACKLIN, FREDERICK R., Miami, Fla.
MAN, EDWARD H., Mamaroneck, N. Y. (Rt and T)
MARKIEWICZ, VICTOR JOHN, North Hollywood, Calif.
MASON, J. HAMILTON, Los Angeles, Calif.
MAUK, HENRY S., Wilmington, Del.
MEALY, JOHN T., Bayside, N. Y.
MITCHELL, THOMAS A., JR., Rochester, N. Y.
MORKOVIN, MARK V., Ann Arbor, Mich.
MORRIS, WALTER K., Silver Spring, Md.
MOSIER, EDWIN K., Closter, N. J. (Rt)
MYERS, EUGENE H., York, Pa.
NEVILLE, GARTH E., Acton, London, England
NIAL, WALTER R., Troy, N. Y.
NOBLE, ARTHUR LYNN, New York, N. Y.
NOROD, SALVATORE A., Frankfort, N. Y.
OGLE, JAMES A., JR., Woodstock, Ill.
ORR, SAMUEL M., JR., Winston-Salem, N. C.
PALMERS, R. M., Liége, Belgium
PARKINSON, WALLACE JAMES, Coraopolis, Pa.
PARMELY, OLIVER C., Rock Hill, Mo.
PATTERSON, RICHARD KINGSBURY, Wollaston, Mass.
PETZINGER, CLARENCE F., Cleveland, Ohio (Rt and T)
PILKINGTON, H. E., Chester, Pa.
POWELL, E. BADEN, Pasadena, Calif.
PRADHAN, R. P., Gwalior, India
REUTER, J. WARREN, Detroit, Mich.
ROBERTS, JAMES G., Portland, Oreg.
ROBINS, HYMAN DON, Los Angeles, Calif.
ROGERS, GEO. D., Miami, Fla.
RUETER, EARLE F., Milwaukee, Wis.
SEIB, FRED A., Long Beach, Calif.
SIMON, HERMAN P., Bronx, N. Y.
SIVER, C. A., East Williston, L. I., N. Y.
SMOOT, DAVID K., Kansas City, Mo.
SORENSEN, WILLIAM R., Manchester, Pa.
STEVENSON, JOHN MCA., Bartlesville, Okla.
STODDART, WILLIAM DAVIS, New York, N. Y.
TEJWANEY, RAM TECKCHAND, Fort Wayne, Ind.
TELLER, MARTIN P., Philadelphia, Pa.
THIOPEN, J. J., Ruston, La.
THRUSH, THORLE H., Cleveland, Ohio
TUTTLE, E. X., JR., Detroit, Mich.
VAN SICKLE, ROY EUGENE, Martinez, Calif.
VOELKEL, C. M., JR., New Orleans, La.
WAIT, J. R., JR., Houston, Texas
WALKER, EMIL C., Chicago, Ill.
WARD, M. M., Cleveland Heights, Ohio (Rt and T)
WHITCOMB, C. C., JR., Carpinteria, Calif.
WILKES, EDMUND, 3RD, Sherman Oaks, Calif.
WILLIAMS, ROY B., Wynnewood, Pa.
WILSON, JAMES C., Charlotte, N. C.
WORTH, W. LESLIE, JR., Mertztown, Pa.
WUNSCH, ERIC M., Brooklyn, N. Y.
ZIESMER, BERNARD U., Milwaukee, Wis.

CHANGE IN GRADING

Transfers to Member or Associate

BATORI, STEPHEN M., Seattle, Wash.
BENECKE, ROBERT O., Omaha, Neb.
BOYNTON, WENTWORTH D., Baltimore, Md.
COCHRAN, JOHN RICHARD, Newton, Iowa
DAVENPORT, GORDON HENRY, Northampton, Mass.
DAVIS, LOUIS E., Berkeley, Calif.
FARLEY, JAMES J., Philadelphia, Pa.
FRIDSTEIN, ROBERT B., Chicago, Ill.
FULLER, DUDLEY D., New York, N. Y.
GOODWIN, BENJAMIN S., Aberdeen Proving Ground, Md.
GRAPNEL, STEFAN L., Putnam, Conn.
HALL, ALLEN S., JR., West Lafayette, Ind.
HARSZY, CHARLES H., Belleville, Ill.
HAUSMANN, WILLIAM, Maplewood, N. J.
HOMSHER, R. LEE, Lancaster, Pa.
LEUSSLER, ARTHUR JULIAN, Clayton, Mo.
MIROFF, WILLIAM V., Los Angeles, Calif.
POLANER, JEROME L., Newark, N. J.
REINHARDT, ALBRECHT, Flourtown, Pa.
RINGLE, CHARLES L., Milwaukee, Wis.
SCHWARZ, ARTHUR H., Birmingham, Mich.
SENNSTROM, HAROLD R., Schenectady, N. Y.
SHANNON, ROBERT H., Havertown, Pa.
STEINMAN, JOHN O., Edwardsville, Ill.
TANGEMAN, WALTER W., Cincinnati, Ohio

Transfers from Student Member to Junior . . . 400

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., in co-operation with the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to all engineers, members or not, and is operated on a nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrant members whose availability notices appear in these columns. Apply by letter, addressed to the key number indicated, and mail to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available at a subscription of $3.50 per quarter or $12 per annum for members, $4.50 per quarter for nonmembers, payable in advance.

New York 8 West 40th St. | **Chicago** 84 East Randolph Street | **Detroit** 100 Farnsworth Ave. | **San Francisco** 57 Post Street

MEN AVAILABLE[1]

CHIEF INDUSTRIAL ENGINEER, PRODUCTION MANAGER, OR ASSISTANT PLANT MANAGER, 31, BSME. Ten years' experience in supervision, production, manufacturing processes, tooling, methods, plant layout, wage incentives, time study, cost control, cost reduction, job evaluation, machining, fabrication, welding, punching, stamping, painting, assembly, cost estimating. Ohio license. Me-512.

MECHANICAL ENGINEER, BS, MME, expects professional license New York State in September. Four years' heavy experience industrial power plants; design, testing, and operation. Me-513.

GRADUATE MECHANICAL ENGINEER, 23, BSME. One year's experience in mechanical sales. Interested in sales engineering. Desires active position with opportunity and responsibility. Will relocate for opportunity. Me-514.

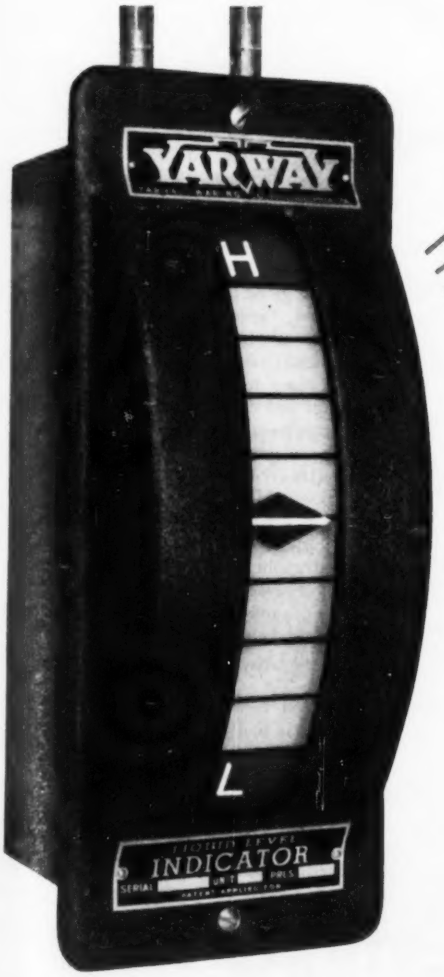
DEVELOPMENT ENGINEER, 46, PE, N. Y. wide experience in production mechanization, design of plants, conveyers, automatic machinery, dies, tooling, hydraulic, pneumatic, and electrical systems, continuous metal casting.

(*ASME News continued on page 886*)

[1] All men listed hold some form of ASME membership.

S.S. ESSO ZURICH boilers guarded by YARWAY INDICATORS

Yarway Remote Indicators on the Esso Zurich: Left to right, hooked-up to starboard boiler, port boiler, deaerator heater.



In marine equipment, few things count more than *dependability*.

That's the reason why many ships like the *Esso Zurich* use Yarway Remote Boiler Water Level Indicators.

With Yarways, boiler water level indication is *instant* and *accurate* because the indicator is operated by the boiler water level itself. Indicating mechanism is never under pressure. No stuffing boxes—operation is frictionless.

Location of the Yarway Remote Indicator may be at any convenient spot desired. Use of new Yarway Control Unit also makes possible multiple horns or signal light alarms.

For 24-hour recordings of boiler water levels, the Yarway HI-LO-GRAPH Recorder is also available.

Write for Bulletin WG-1822

YARNALL-WARING COMPANY
108 Mermaid Ave., Philadelphia 18, Pa.
Branch Offices in Principal Cities

YARWAY **REMOTE LIQUID LEVEL INDICATOR**

Desires responsible position anywhere. Me-515.

MECHANICAL ENGINEER, 38, with fifteen years' experience plant management, production, and engineering diversified industries, seeks responsible position in medium-sized manufacturing plant. Adaptable, aggressive, with excellent record of labor relations. Me-516.

MECHANICAL ENGINEER, 40, degree, diversified experience in operation and supervision of steam and power-generation plants. Some experience with refrigeration and water plants. Some plant layout, estimating, and construction supervision. Six years' in supervisory capacity. Desires administrative-engineer position in power plant or utility. Midwest, West. Me-517-122-M.

MECHANICAL ENGINEER, 30, married, three and a half years' experience product and methods engineering for wood and metal-working shops, product-finishing background, plant layout, cost reduction, cost estimating. Eastern U. S. Me-518.

MECHANICAL ENGINEER, 23, married, BE. Three years' experience: power plant, Diesel-electric power, electric control. Ex-Navy officer. Desires operating, maintenance position. Me-519.

JUNIOR MECHANICAL ENGINEER, 25, BME, Cooper Union, recent graduate, T.B.P. Single. Prefers internal-combustion field, but will take any position which will provide experience and a future. Me-520.

EXECUTIVE ENGINEER, chemical and mechanical. Twenty years' diversified experience. Supervision of plant and process development, design, construction, and operation. Equipment design and applications. Sales and consulting. Project management. Me-521.

RECENT BROWN UNIVERSITY GRADUATE, cum laude, in mechanical engineering. Single, 21. Will locate anywhere. Me-522.

MECHANICAL ENGINEER, PE, ME. Product design and development engineer. Twenty-five years' experience in domestic and industrial hydraulic equipment, metalworking, and automatic machinery. Metropolitan New York area. Me-523.

MECHANICAL ENGINEER, recent graduate, desires employment in South America or West Indies. Twenty-nine months' experience aboad ship as assistant or chief engineer. Also graduate of U. S. Merchant Marine Academy. Me-524.

MECHANICAL ENGINEER, 33, married and one child, State University of Iowa BSME, ten years' experience in maintenance, field engineering, and machinery and construction, supervision and production planning of manufactured machinery, design, detail, and installation of grain-handling and processing machinery. Desires a permanent position where good over-all engineering ability will be a valued asset. Me-525.

MECHANICAL ENGINEER, 24, single. Recent graduate. BME, C.C.N.Y. Desires position with future. Interested in heat and power, internal-combustion fields. U. S. A. Me-526.

MECHANICAL ENGINEER, 24, single, BME, recent graduate. Desires position in maintenance or testing, but will take any position that will provide experience and a future. Anywhere in the United States. Me-527.

MECHANICAL-ENGINEERING GRADUATE, two years' business at NYU, 30, married. Twelve years' experience principally performing cost accounting, all phases of plant and central accounting, office procedures, production, and inspection. Me-528.

ENGINEER, 27, BME, 1949, married. Four years' experience in operation and maintenance of steam and Diesel power plants to 10,000 hp, licensed marine and stationary, nine months' inspection metal processing. Will locate or travel anywhere. Me-529.

GRADUATE MECHANICAL ENGINEER, 26, single; one and a half years with general building contractor as assistant to project manager; three years' experience in machine shop and toolroom. Construction field preferred. Me-530.

RECENT GRADUATE, 29, married, BSME, desires position in heating and air-conditioning field; however, will consider any good offer. Experienced aircraft-engine mechanic and inspector. Me-531.

INDUSTRIAL ENGINEER, June, 1949, graduate, 26, single. Sigma Tau. Desires time-study or methods work. Prefers textile or metal-working industries. East or Midwest. Me-532.

POSITIONS AVAILABLE

ENGINEERS. (*a*) Chief engineer, experienced, to take charge of the design, both for selling and production of such products as special industrial and institutional trucks and similar products. (*b*) Engineer with some experience on methods-engineering work. Should be able to develop jigs and fixtures for use in the quantity production of metal parts, and should have imagination and initiative. Ohio. Y-2650-C.

DESIGNER, 35–45, mechanical graduate, with at least ten years' automatic-machinery-design experience, to make layouts from design sketches of packaging and printing equipment. Prefer resident of New Jersey. $6000. New York at present; later, New Jersey. Y-2719.

ENGINEERS. (*a*) Mechanical engineer, 35–45, with professional license, to serve as assistant to manager of engineering department, supervising and directing other engineers and draftsmen on plant layouts, material handling, medium-sized power plants, and general industrial-plant repairs, etc. Some traveling. Must be able to work with plant managers in different places. Salary open. (*b*) Machine designer, 35–45, to head machine-design section of manufacturer's engineering department. Must be able to direct and supervise work of other designers and draftsmen on high-speed, lightweight automatic machinery. Salary open. Eastern Ohio. Y-2734.

MECHANICAL, ELECTRICAL, AND CIVIL ENGINEERS, 30–35, with three to five years' experience in oil-refinery design and construction, to perform staff engineering assignments and supervise estimating, designing, and construction of town sites, public-utilities and oil-refinery process equipment. $6500 plus bonus. Family housing available sometime in the future, therefore must go single status for an indefinite period. Venezuela. Y-2741.

INSTRUCTOR, mechanical or aeronautical graduate, with at least a bachelor's degree, to teach theoretical mechanics and mechanical engineering laboratory. $3150. East. Y-2750.

INDUSTRIAL ENGINEER, 35–50, engineering graduate, with at least ten years' industrial engineering experience in steel mills, to review incentive program, set up new standards, etc., for alloy-steel company. $6000–$7500. East. Y-2755.

POWER ENGINEER, mechanical graduate, about 35 years of age, familiar with design and testing of large power boilers and allied equipment for staff position with boiler-equipment manufacturer. $5000. Eastern Pennsylvania. Y-2767.

MECHANICAL ENGINEER, graduate, for central engineering staff of large company, who has had some experience on maintenance and mechanical problems of mining equipment, to make investigations and reports. Should have an interest in solving diversified problems. Some thermodynamics or heat-transfer experience desirable. Will consider a mining engineer who is familiar with mechanical problems. Some traveling, but over one half of time will be spent in headquarters in Chicago, Ill. Salary open. Y-2773-C.

MECHANICAL ENGINEER, 30–35, with three to five years' domestic oil-and-gas home-heating-equipment experience to design and lay out forced-warm-air furnaces. $6000. Northern New Jersey. Y-2783.

PLANT ENGINEER, 35–45, mechanical graduate, with at least ten years' supervisory experience as plant engineer in large company in the casting, extrusion, forging, and machinery of brass, bronze, copper, and aluminum fields, to take charge of maintenance, plant layout, construction, and powerhouse operations. $7500–$10,000. Midwest. Y-2784.

MECHANICAL ENGINEER, 30–40, with at least five years' materials-handling experience in package and case fields, to survey and lay out improvements covering trucks, conveyers, etc. Considerable traveling. $5200–$6500. Headquarters, New York, N. Y. Y-2792.

ASSISTANT MANAGER, 30–35, preferably mechanical graduate, with experience in the production of oxygen and acetylene and their industrial application, to supervise operation and maintenance of plant, schedule cylinder shipments, and furnish customers with technical aid on welding and cutting problems. $6000 plus bonus. Trinidad, B.W.I. Y-2797.

INDUSTRIAL ENGINEER, preferably mechanical, who has had five or more years', good, diversified engineering experience, for office of a consultant. Some traveling. Salary open. New York, N. Y. Y-2800.

SENIOR INDUSTRIAL ENGINEERS, 35–45, with time-study and wage-incentive experience, (*a*) covering machine shop and general metal-working; (*b*) covering textile-garment industry, for staff positions with consultant. Considerable traveling. $6000–$8000. Headquarters, New York, N. Y. Y-2803.

DESIGNERS, under 45, mechanical graduates, with minimum of five years' design experience on heavy equipment such as gears, and shafting for crawler tractors, cranes, draglines,

(*ASME News continued on page 888*)

shovels, winches, and other hoisting machinery. Capable of assuming responsibility and following through to completion. Experience with hydraulic controls and automatic transmission also desirable. Salary, about $6000. Northern Indiana. R-5849.

INDUSTRIAL ENGINEER, 40–48, with fifteen years' background with factory methods on time study; knowledge of elemental standards; informed about consulting process and client's requirements. Will do time studies and method work, establish wage-incentive programs. Production control, cost and budgetary control desirable for a consulting firm. About $6000. Chicago, Ill. R-5854.

METHODS ENGINEER, substantial experience with improvement of labor utilization in connection with candymaking or other related processes for a manufacturer. $6000. Middle South. R-5864.

ASSISTANT MECHANICAL SUPERINTENDENT, 28–35, with four to eight years' experience in industrial-plant maintenance department; knowledge of building design, construction, and erection, including heating, piping, illumination, ventilation, some steam-plant, and large refrigeration experience desirable. Informed on plant layout and planning. Will lay out, check, supervise, and inspect new installations of equipment and machinery. Must be willing to do board work and be a good draftsman and detailer. $5000–$5500. Chicago, Ill. R-5866.

TEACHING PERSONNEL. (*a*) Professor, department head, mechanical engineer, 40–55, master's degree, but preferably PhD. Considerable amount of industrial and teaching experience. Will be responsible for the operation of the department. $7000. (*b*) Assistant professor, mechanical engineer, master's degree, college-teaching experience necessary, some industrial experience desirable. $4400 for nine months. (*c*) Professor, department head, 40–55, PhD. Considerable amount of college-teaching experience, including positions of responsibility in physics department. Reasonable amount of industrial experience desirable, but not required. Some contact with engineering education desirable. Will be responsible for the operations of the department. $7000. (*d*) Associate professor in physics, PhD. Some college-teaching experience, industrial experience desirable. Specialization expected in electricity, with reference to electrical measurements and electronics. $4400 for nine months. (*e*) Assistant professor in mathematics, PhD or well-qualified man with master's degree. Should have teaching experience in college mathematics. $3800 for nine months. (*f*) Associate professor, master's degree in mechanical engineering, with several years' teaching experience, professional experience desired but not required. Will teach mechanical-engineering courses in a technical and mining school. $3600–$4600 for three terms. Midwest. R-5869.

MECHANICAL ENGINEER, graduate, with mechanical-engineering construction of mining and chemical-process facilities. Knowledge of this work in connection with handling and treating of bulk materials in large quantities for a mining and manufacturing company. $7200–$8400. Illinois. R-5875.

SERVICE AND REPAIR ENGINEERS, mechanical graduates, with extensive experience using, installing, and directing service and repair of automotive, Diesel, electric motors, generators, transformers, starters, earth-moving equipment, pumps, and compressors. Thorough knowledge of subassemblies, spare parts, and interchangeability. Successful supervisional experience with equipment-distributors' service or in management and operation of large storehouse controlling and determining spare-parts stock desirable for a management consultant. $6000. Headquarters, Chicago, Ill., with some traveling. R-5902.

Obituaries

David Fowler Atkins (1868–1949?)

DAVID FOWLER ATKINS whose death has been reported to the Society, was a consulting engineer, Flushing, L. I., N. Y. Born, Westfield, Mass., Dec. 12, 1868. Parents, William H. and Annie (Wilson) Atkins. Education, BSME, Worcester (Mass.) Polytechnic Institute, 1891. Married Helen Burgess, 1900; two children. Mem. ASME, 1907.

H. Kirke Becker (1887–1949)

H. KIRKE BECKER, president of Peters Machinery Co., Chicago, Ill., died of a heart attack on June 21, 1949. His home was in Winnetka, Ill. Born, Forest City, Ark., May 20, 1887. Parents, Alexander and Fannie (Lewis) Becker. Education, ME, Cornell University, 1911. Married Rosalind E. Gans, 1916; children, Jane G., Rosalind A., Kirke, and Elizabeth A. Assoc-Mem. ASME, 1919; Mem. ASME, 1935. Survived by wife and four children.

Charles Burnham (1880–1949)

CHARLES BURNHAM, retired designer of automatic machinery and owner of Burnham Basket Co., Los Angeles, Calif., died of a cerebral hemorrhage at the Washington Sanitarium and Hospital, Takoma Park, Washington, D. C., on June 6, 1949. Born, Norwich, Conn., March 14, 1880. Parents, Charles Abbot and Catherine (Hanman) Burnham. Education, public schools; ICC. Married Beatrice C. MacBride, 1910. Assoc.-Mem. ASME, 1917; Mem. ASME, 1935. Survived by wife and son, Charles Jamison Burnham.

Charles David Burtenshaw (1895–1949)

CHARLES D. BURTENSHAW, director in charge of engineering, Pulverizing Machinery Co. Summit, N. J., died June 22, 1949. Born, Brooklyn, N. Y., Feb. 9, 1895. Education, ME, Stevens Institute of Technology, 1922. Married Gertrude Hansen, 1944. Jun. ASME, 1922; Mem. ASME, 1935.

Peter Cherdantzeff (1892–1949)

PETER CHERDANTZEFF, assistant engineer, Consolidated Edison Co., New York, N. Y., died in Amsterdam, N. Y., July 25, 1949. He had made his home in New York, N. Y. Born, Petropavlovsk, Russia, Feb. 4, 1892. Educated, Polytechnic Institute of Petrograd, Russia; ME, Cornell University, 1921. Married Ina Bray, 1925. Jun. ASME, 1922; Assoc-Mem. 1925; Mem. 1935. Served on Power Test Code Committee No. 6 from 1945 until the time of his death. Survived by wife.

Arminger Faulknor Dredge (1892–1949)

ARMINGER FAULKNOR DREDGE, consulting engineer, died June 26, 1949, at his home in Oakland, Calif. Born, Oakland, Calif., Aug. 7, 1892. Parents, Theo Faulknor and Agnes (Young) Dredge. Education, University of California, Berkeley, Calif.; Battersea Polytechnic, London, England. Married Beulah May Westherford. Mem. ASME, 1941. Survived by wife and son, Arminger Faulknor Dredge, Jr., San Leandro, Calif.

Nelson Crawford Durand (1868–1949)

NELSON C. DURAND, an associate of the late Thomas A. Edison in the development of incandescent lamps and voice-writing equipment, retired vice-president of the Ediphone Division of Thomas A. Edison, Inc., died at his home in East Orange, N. J., on July 19, 1949. Born, Newark, N. J., June 28, 1868. Parents, William Baldwin and Jennie (Thompson) Durand. Education, Newark (N. J.) technical schools. Married Elizabeth Parmly, (1901) (deceased, 1947); children, Margaret and Louise. Mem. ASME, 1899. Survived by daughter, Mrs. Stuart Tucker Morrin.

Adalbert Harding (1872–1949)

ADALBERT HARDING, retired sales engineer, died at the St. Francis Hospital, Port Jervis, N. Y., on July 8, 1949. Born, Boston, Mass., Feb. 12, 1892. Parents, William Penn and Abbey Anceline (Morse) Harding. Education, AB, Harvard University, 1894; ME, Cornell University, 1897. Married Olive Brown, 1915. Jun. ASME, 1898. Survived by wife.

Edward Phinly Morse, Jr., (1882–1948)

EDWARD P. MORSE, JR., consulting marine engineer, died April 9, 1948. Born, Brooklyn, N. Y., May 14, 1882. Parents, Edward Phinly and Ada Morse. Education, Pratt Institute and Cooper Union. Married Margaret Crittenden, 1900; children, Hallette, Janice, Susan, Thora, and Gloria. Mem. ASME, 1918.

Edward Brevoort Renwick (1863–1949?)

EDWARD B. RENWICK, retired real-estate and corporation-management consultant, died early in 1949. He had made his home in Short Hills, N. J. Born, New York, N. Y., April 21, 1863. Education, ME, Stevens Institute of Technology, 1884. Mem. ASME, 1914.

Earl Lewis Ridley (1898–1949)

EARL L. RIDLEY, plant engineer, Thompsonville (Conn.) plant, Bigelow-Sanford Carpet Co., Inc., died May 2, 1949. Born, Fall River, Mass, June 21, 1898. Parents, Lewis F. and Mabel F. Ridley. Education, public schools; Bradford Durfee Textile School, England. Married Alice E. Dary, 1920; children, Alden and Bryce. Assoc-Mem. 1929; Mem. 1935.

William Bell Wait (1872–1949)

WILLIAM B. WAIT, president, Valve Pilot Corp., New York, N. Y., died at the N. Y. Yacht Club where he made his home, June 26, 1949. Born, New York, N. Y., July 13, 1872. Parents, William Bell and Phebe Jane (Babcock) Wait. Education, LLB. 1894; LLM. 1895, both degrees granted by Columbia University. Mem. ASME, 1942. Survived by a sister, Mrs. Frank Battles, Wayne, Pa.